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WALNUT CULTURE IN CALIFORNIA
WALNUT BLIGHT

BY

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WALNUT CULTURE IN CALIFORNIA.

WALNUT BLIGHT.

By Ralph E. Smith.

Assisted by Clayton O. Smith and Henry J. Ramsey.

The present bulletin represents the results of the most extensive, and, perhaps, the most important investigation undertaken by the department of plant pathology since its foundation. When the writer first came to California in 1903, one of the most conspicuous and most serious plant diseases then prevalent in the State was the so-called walnut blight. The disease, while comparatively a new one at that time, had reached all the important walnut-growing districts and was reputed to have been the cause of a diminution of at least one half in the walnut crop of the State. The trouble had been under investigation for some little time by Professor Newton B. Pierce, then of the United States Department of Agriculture, who had succeeded in definitely establishing its cause and had undertaken considerable work along the line of treatment for its suppression, and also that of developing varieties of the walnut which might be immune to this disease. Professor Pierce, however, was burdened with much other work, which prevented his giving to walnut blight the amount of attention which the walnut growers felt that the subject justified; indeed, the importance of the matter, owing to the extensive ravages of the disease, seemed to justify every possible effort toward finding means for reducing the great losses occasioned by this trouble. The walnut growers' associations had, therefore, offered a standing reward of twenty thousand dollars for a feasible remedy for the blight, and were eager to demand all possible assistance in solving this problem. The legislature of 1905 made an appropriation of four thousand dollars to the Regents of the University of California, directing them to cause to be prosecuted investigations looking for a remedy for the walnut blight, and under this appropriation the present work was started.

In the spring of 1905 a laboratory was established in the city of Whittier, Los Angeles County, primarily for the study of walnut blight. This laboratory was placed in charge of Mr. Albert M. West, an experienced bacteriologist, who, under the direction of the writer, commenced the investigations which are reported in this bulletin. The work was largely contributed to in later years by Messrs. Clayton O. Smith and Henry J. Ramsey, the latter working particularly upon the pomological side of the investigation, while Mr. Smith's work has been

largely confined to the study of the bacterial organism which is the cause of the disease.

It was found early in the work that the problem was much broader than one simply of bacteriology or plant pathology proper, and as the investigation developed, it became necessary to study the whole subject of walnut culture from a horticultural or pomological standpoint. The establishment of the Southern California Plant Disease Laboratory at Whittier as a permanent institution made such work possible. Soon after the location of this laboratory, space was obtained on the grounds of the Whittier State School for orchard planting of walnuts. Upon this ground there was commenced, in the spring of 1907, an experimental walnut orchard, in which may now be seen representative trees of all the important varieties. Upon the same grounds, and also those of the laboratory proper, a large amount of nursery work was also commenced in connection with the study of methods of propagation of the walnut, testing of different roots and other similar subjects. In 1909 this portion of the work was mostly transferred to the Pasadena City Farm near Alhambra, where it could be carried out on a much larger scale. In addition to nursery experiments, considerable work has also been done in the vicinity of Whittier and in other places in top-grafting walnut trees in the orchard with the idea of determining the feasibility of working over undesirable trees to better varieties. Much work has been done in searching for desirable walnut trees all over the State, and such trees when found have been tested out quite extensively by propagation, both in the nursery and upon old trees, as mentioned above. A large amount of top-working of this sort has been done upon the Pasadena City Farm, where a large seedling walnut orchard already existed, and also in conjunction with several growers in various parts of the State. Scions and nursery trees of promising varieties have also been distributed quite extensively during the past three or four years. In this way many new varieties will be tested in various parts of the State much more quickly than would otherwise have been the case. Considerable testing of root stocks has also been brought about by the same means. A line of work similar to that at Whittier has also been inaugurated on the University Farm at Davis, and it is hoped that this work may be continued and extended there on account of the growing importance of the walnut industry in the northern part of the State. As now presented, the results of this investigation cover practically all phases of the subject of walnut culture in California, both north and south.

The English or Persian walnut, *Juglans regia,* constitutes one of the most important and one of the most attractive tree crops of California. In southern California, to which portion of the State the crop on a

commercial basis has thus far been largely confined, the walnut is second only to the orange in prominence. Under favorable and normal conditions walnut growing is one of the most attractive horticultural pursuits which can be imagined. The trees require comparatively little care compared with citrus fruits, and they are subject to comparatively few pests or diseases. The price of the crop has been almost invariably good, and first-class walnuts have always sold readily at excellent prices. The product is not subject to decay, freezing, or other dangers which are common to most fruit crops. No unusual skill is required to conduct a well-established walnut grove, and all in all this crop is, as said above, perhaps the most attractive and the best adapted to the average settler coming to California when favorable conditions for its production obtain.

Unfortunately, this bright picture of the walnut industry has been seriously marred during recent years by the disease above referred to, and various evils which have been more or less attendant upon it. Fortunately, however, the prospects of the industry are at present very much brighter than they have been in the recent past, and there is now every reason to believe that walnut growing is again coming into its own upon a new and better basis, as one of our best horticultural pursuits. The walnut has been grown in California to a greater or less extent since the early days of white settlement, but it is only within about the last twenty-five years that the crop has assumed the rank of an important horticultural product. Up to about 1900 the production of walnuts in the State rapidly increased, reaching an amount in that year which was not exceeded until 1911, and which fell off nearly one half during the intervening period. Until very recently about the whole commercial crop was produced in southern California, and almost exclusively in the counties of Santa Barbara, Ventura, Los Angeles, and Orange. In these counties, which still contain by far the bulk of our walnut acreage, there is probably at present more than thirty thousand acres of walnuts, young and old. It was thought at first that this portion of the State was the only one adapted to this crop, but later experience has shown this idea to be erroneous; and especially since land values have become so high in much of the southern California walnut country, and the citrus industry has extended over much of the available walnut land of that portion of the State, the walnut has commenced to go north, so that at present there is a strong indication that large walnut districts in the future may be found in the central portion, probably within a radius of one hundred and fifty miles from San Francisco, as well as in the southern districts.

FIG. 1.—Bloom of English walnut, showing catkins (A) coming from the old wood, and the new growth and leaves with two young nuts or pistillate blooms (B) at the end.

THE ENGLISH WALNUT.

(Juglans regia.)

"*Juglans regia,* which is a large and lofty tree with stout, spreading branches, is probably indigenous to the mountains of Greece, in Armenia, in the region south of the Caucasus and the Caspian Sea, on the northwestern and northern Himalayas, and in Burmah (A. de Candolle, Origine des Plantes Cultivées, 342). It was cultivated in northern India in very early times, and carried then to China, where it is still grown on a large scale (Bretschneider, On the Value and Study of Chinese Botanical Works, 16; Early European Researches into the Flora of China, 174). It is probably not indigenous, however, to China, nor is there any evidence that this tree is a native of Japan, as many authors have believed, although it is occasionally seen in that country in the neighborhood of human habitations. The Greeks cultivated a variety of this tree obtained from Persia; the Romans carried it to Italy, whence its cultivation as a fruit tree has spread through all the countries of southern and western Europe, the Pacific states of North America, Chile, and other temperate regions. The nut of the wild tree is small, with a thick, hard shell and small kernel, and is scarcely edible."*

The walnut tree is naturally of rapid and thrifty growth, and forms an attractive, decidedly ornamental tree, with a clean trunk and tall, spreading top. The bark of the young growth is usually of a dark green color with a smooth, glossy appearance, that of the larger limbs light colored or nearly white and fairly smooth, with a trunk of the same appearance, the bark remaining smooth until the tree becomes of considerable age and size. The fruit is a true nut, being borne in an outer, fibrous, rather fleshy enveloping husk or shuck, which opens and allows the nut to drop out freely when matured. The walnut in its best commercial form is one of the best of nuts, being of good size, attractive appearance, easily cracked, and having a kernel of pleasing flavor and attractive appearance, which is readily removed from the shell. It is also healthful and nutritious and a valuable article of food.

The foliage of the tree is composed of large, compound, pinnate leaves, which are deciduous in the fall. The flowers are of two kinds, staminate and pistillate (male and female), both born on the same tree. The staminate blossoms are born on long, pendulous catkins, which develop in spring from naked buds already formed on the twigs of the preceding year. These catkins contain an abundance of light, dusty, yellow pollen, which is carried by the wind to the pistillate or fruiting

*Sargent, Silva of North America.

blossoms. The latter are produced at the tips of young shoots coming out in the spring from terminal buds on twigs of the previous year's growth. These consist of miniature nuts, or ovaries, each bearing at its

FIG. 2.—Mature walnuts, dropping from shucks. (Courtesy Kruckeberg Press.)

extremity a two-branched, feathery stigma, which is designed to catch the pollen coming in the air from the catkins. After pollination the stigmas wither away and the pistillate flowers develop into nuts. In

California most of the blooming takes place in April and May, although some unusually early or late trees bloom previous to or later than this period. The nuts commonly mature during September and October.

The English walnut grows readily from seed, if the nuts are not allowed to become too dry, and are planted with plenty of moisture during the spring following their production. The seedlings are of strong and vigorous growth, but in this species do not usually make very much growth in height during the first season. A large taproot is formed, usually longer and thicker than the stem above ground. The latter remains comparatively short during the first year, but makes very much more growth the second year. Trees averaging only about one foot in height at the end of the first year will frequently make a growth of ten or twelve feet, or even more, the second year. Seedling trees, though varying widely, are usually vigorous, thrifty and long-lived, so long as soil and climatic conditions are favorable. The English walnut on its own root, however, has little adaptability to unfavorable conditions, and is very easily injured or killed by lack of moisture, excessive moisture, poor soil, or other unfavorable conditions. While a long-lived tree in the Old World, growing in regions of abundant natural rainfall, the seedling walnut has proven itself much shorter-lived in California, and many of the older groves have largely died out. There are a few trees in the State close to sixty years of age, but these are mostly in the northern part, where the rainfall is fairly abundant. In the south many trees and groves planted less than forty years ago have almost entirely died out, largely on account of an uncertain or irregular supply of soil moisture.[1]

The seedling English walnut is rather slow in coming into bearing, most trees producing very few nuts until the fifth or sixth year after planting or even later. Different trees, however, vary widely in this respect. The production per tree also varies greatly. The average product per year for the older seedling groves of the State is scarcely more than 50 pounds per tree, although many individual trees far exceed this. One hundred pounds per tree at an age of fifteen to twenty years may be considered quite satisfactory, according to present production, while some individual trees of particularly large size and heavy bearing qualities, run up to 300 pounds or a little more. There are a few very large old seedling trees in the State, standing in good soil with no other trees close about them, which have produced as high as 400 or even 500 pounds of nuts per year, but this is very exceptional and cannot be considered on the same basis with trees planted in

[1]Lelong (Rep. Cal. Bd. Hort. 1895–96) quotes accounts of Old World walnut trees of ten, fifteen or even more feet in diameter and bearing as much as 2,000 pounds of nuts per year. One of these trees is estimated to be at least 1,000 years old. See *Gardners' Chronicle,* London, 1852, p. 568; 1857, p. 694; 1877, p. 310.

orchard form.[1] If walnut trees could be obtained which would average 200 pounds of good nuts per tree in the orchard, the profits from such a planting would probably equal the average returns from citrus groves, while 300 pound trees would be even better than the latter in the long run. Since such trees already exist in individual cases, there is no reason to doubt that it may ultimately be possible to produce commercial orchards of this sort.

During the many years during which the walnut has been under domestication, both in the old world and the new, it has, like all other cultivated plants, come to vary to a large extent in individual trees in regard to the characteristics of the tree, and particularly in regard to the size, form, flavor and other qualities of its fruit. Likewise, as with other crops, certain individuals of superior merit of one sort or another have been noted from time to time, and many such individuals have been given definite names as special varieties and the peculiar properties of these varieties have been perpetuated by budding or grafting. In this way we have many definite varieties of the walnut, just as with the apple, peach and other fruits. In a broader way, the walnut has also become broken up into certain more or less well-defined types, which come true to a certain extent from seed.

OTHER SPECIES OF WALNUT.

A considerable number of walnut species is found in various portions of the world, in addition to the cultivated form, *Juglans regia*. "*Juglans* is now confined to the temperate and southern parts of North America, the Antilles, South America from Venezuela to Peru, the Caucasus, Persia and northwestern India, Manchuria, northern China, and Japan. About ten species are known; two are widely distributed in the forests of eastern North America; one inhabits western Texas, New Mexico, and Arizona, ranging far south into Mexico, where one and perhaps two other species occur; and one inhabits the valleys of western California. The flora of the Antilles contains a single species of *Juglans,* while two or perhaps three others occur in the northern and western countries of South America. In the old world the genus is represented by *Juglans regia,* an inhabitant of southeastern Europe and western Asia and now cultivated in all temperate countries, by *Juglans mandshurica* of the Amur valley and northern China, and by *Juglans sieboldiana* of Japan."*

[1]The famous Payne tree, near San José, has produced over 700 pounds of nuts in one year, but this is a large black walnut tree, topworked in the branches.

*Sargent, Silva of North America.

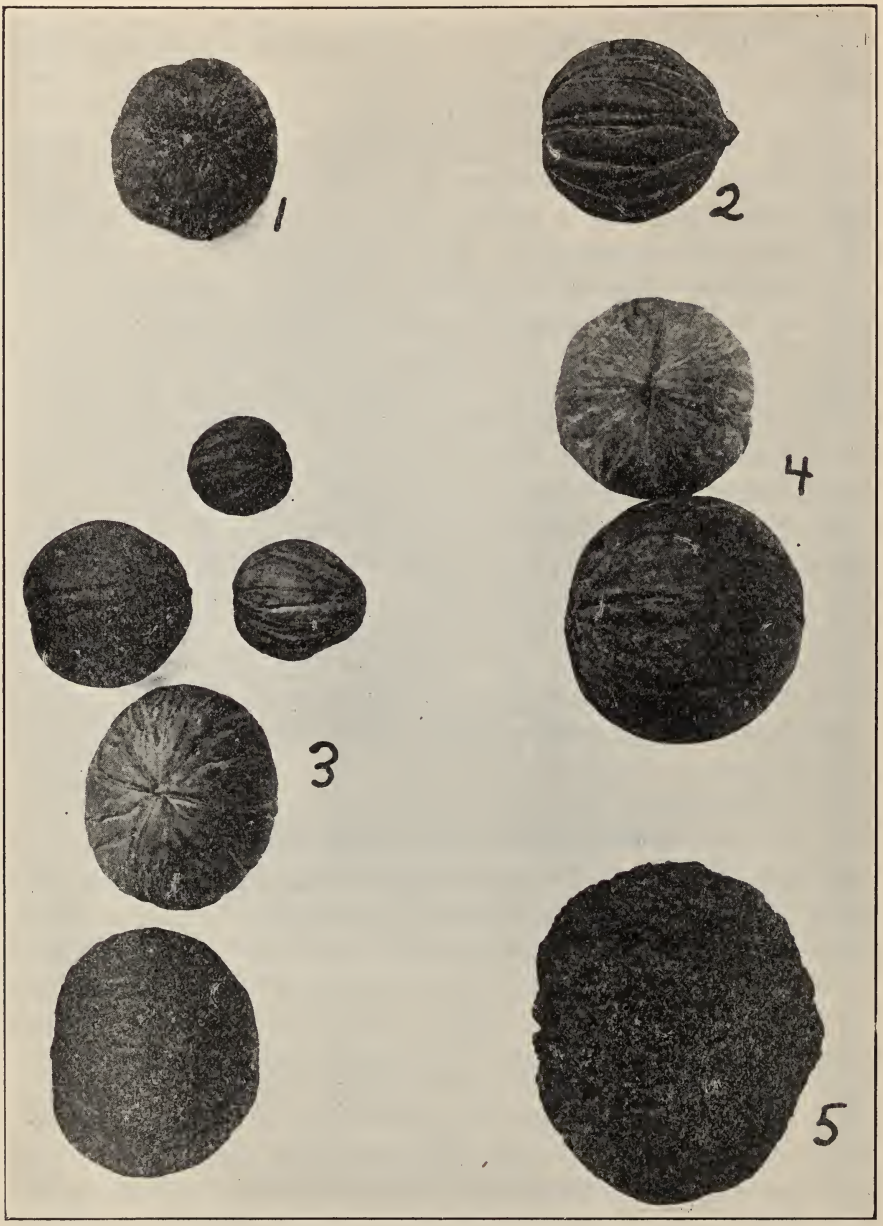


FIG. 3.—Black walnuts. 1, Southern California (*californica*); 2, Arizona (*major*); 3, five different types of *rupestris* from Texas and New Mexico; 4, Northern California (*hindsii*); 5, Eastern (*nigra*).

AMERICAN BLACK WALNUT.

(Juglans nigra.)

This is the native walnut of the Middle West, occurring in river bottoms and valleys from western Massachusetts to Minnesota, southward to Georgia, Florida, Mississippi, and Texas, and forming one of the finest trees of Ohio, Illinois, Nebraska, Kansas, Kentucky, western Pennsylvania and other portions of the Middle West. It is a tall, erect-growing tree with a large, straight trunk covered with deeply-furrowed, narrow-ridged bark. The fruit is large, with a thick husk, containing a nut which is of brown or, when dry, nearly black color, with a hard, thick shell marked on the surface with deep, narrow furrows and prominent, irregular ridges. This tree is not native to California, but was brought here by the first settlers from the East, and has been planted quite abundantly since the early fifties. In California the true eastern species is of very slow growth during its early years, and is distinguished from all others by its very rough nuts. Other conspicuous characteristics are the fact that it is extremely late in coming out in the spring, the trees remaining bare and dormant long after other walnuts are in full leaf, while at the same time, it is one of the first to drop its foliage in the fall. Typical trees of the true *Juglans nigra,* grown from seed introduced from various Middle West States, may be found growing about almost all of the older towns of the State, particularly in the central and northern portions.

CALIFORNIA BLACK WALNUT.

The first American explorers of California found growing here native walnut trees which have been variously classified by botanists. Sereno Watson[1] in 1875 described *Juglans californica* as "A large shrub or tree in the vicinity of San Francisco, growing 40 to 60 feet high and 2 to 4 feet in diameter, and ranging southward to Santa Barbara, southern Arizona and Sonora." He includes in this species what Torrey had previously described as *Juglans rupestris,* var. *major,* stating that "The more eastern *Juglans rupestris* is but 6 to 20 feet high, with more numerous and usually more acuminate leaflets," etc. To the latter species he also ascribes a smaller, thicker walled nut than that of *californica.* Most of the standard works, such as those of Sargent and Britton, follow this arrangement, giving the one species *Juglans californica* for this State, with a range extending over most of the State. Britton[2] states, for instance, page 220, that "This walnut

[1]Proc. Am. Acad. Arts and Sc. Vol. 10:349, 1875.
[2]North American Trees.

occurs in river bottoms and stream banks in western California, extending from Los Angeles County northward to Napa County. It is a very beautiful tree, attaining a height of 60 feet, with a trunk diameter of 20 inches. Sometimes, however, it is reduced to a shrub."

Locally it has long been noted that there are in California two more or less distinct species of native walnut, that of the north and that of the south. Some have classed the southern form as *Juglans rupestris,* but very little observation is necessary to show that the native walnut of southern California is not that which is included under this name. Jepson,[1] in the Bulletin of the Southern California Academy of Sciences, discusses this matter, concluding that Watson undoubtedly had in mind the southern California form, and that, therefore, this must be taken as the type of *Juglans californica.* For the northern form he proposes the name *Juglans californica,* var. *hindsii,* naming it in honor of Richard Brinsley Hinds, botanist of the Sulphur Expedition, who first discovered the California walnut on the lower Sacramento River in 1837. In a later work Jepson[2] again classes all the California native walnuts under the species *californica,* stating that "The northern form, named var. *Hindsii*—Jepson, is characterized by its distinctly arboreous form, tall trunks and larger fruits ($1\frac{1}{4}$ to 2 inches in diameter). Such differences may be readily attributable to the climatic and soil conditions of the northern habitat."

The study of the native California black walnut having become of considerable importance in this work in connection with the subject of rootstocks for the English walnut, we have given no little attention to an effort to determine the true relationships of the black walnuts found growing in various portions of the State. As Jepson and others have noted, there is a marked segregation of these trees into the northern or central and the southern portions of the State, with a broad territory between, in which it is evident that at the present time at least no native walnuts occur.

NORTHERN CALIFORNIA BLACK WALNUTS.

In the upper portion of the State no tree is more conspicuous as a shade and street tree, especially about the older towns, than that which is called the California black walnut. Among these may be found many specimens of the eastern walnut, *Juglans nigra,* which may be easily identified by their rough nuts, late development in spring and early shedding of the leaves in the fall. Excluding these, there remain very numerous specimens of the so-called true California walnut, a

[1]Vol. VII, No. 1, p. 23, 1908.
[2]The Silva of California.

tall, erect-growing tree, having somewhat smaller leaves and nuts and smoother bark than the eastern species, with nuts the surface of which is almost perfectly smooth. This type is popularly supposed to be native to, and commonly distributed in, the northern half of the State. Inquiry soon develops, however, that the majority of these trees have been planted where they now stand within the memory of people still living.

FIG. 4.—Northern California black walnuts, south of Gilroy.

In this way, the history of numerous very fine, large, old trees can be ascertained, the oldest of which are invariably found to have been planted between 1850 and 1860. Such, for instance, are the two very large trees standing by the roadside just south of Gilroy, and numerous specimens about San José, Hayward, Stockton, Vacaville, Winters, Suisun, Santa Rosa, Napa, Colusa, Marysville, Yuba City, Chico, Tehama, and many of the old mining and commercial towns of the

western slope of the Sierra Nevada, the San Joaquin Valley, and on both sides of the Sacramento Valley. In each and every case the history and original planting of these old trees, which represent the largest California black walnut trees in the State, can be definitely ascertained. In his investigations on the subject Jepson found two localities where this tree appeared to have been growing naturally at the time of the advent of the first white settlers. On this point he states as follows:* "There are two centers of distribution, one in the north and one in the south, without connecting localities so far as I have been able to determine. In the north it occurs in the lower Sacramento region, keeping to the banks of the river islands of Andrus, Grand, and others, and along streams in the valleys at the western base of Monte Diablo, specifically on Walnut Creek and Lafayette Creek."

In our investigations conclusions were reached coinciding with Jepson's, that these were two of the original homes of the northern California black walnut, and a third location was added to the list which appeared to be older than either of the other two. This was a station known locally as Walnut Grove, situated on the east slope close to the top of the first divide east of Napa, near Atlas post office. In this locality there exists along the mountain-side, near the top, a series of small ponds or marshes, each consisting of a cup-like depression or terrace in the hillside, about the edges of which discharge several springs. Each of these terraces no doubt contained at one time a small body of water, but in the course of time they have filled up with vegetation and soil into swamps and mud holes. There are some eight or ten of these formations scattered along the hillside within a mile or so, the largest, the northernmost one, having an area of possibly three or four acres. The whole hillside throughout this locality is covered with a dense growth of native trees characteristic of the region, particularly the Oregon maple and black oak, with California laurels and madrones in the deeper cañons. The soil is deep and moist upon this slope, and all vegetation is very luxuriant. On the largest and northernmost of the little basins mentioned there stand, near the north end, three large, black walnut trees, one of which appears to be by far the oldest walnut tree in the State. This consists really of a group of seven good sized trees, all arising from a common base, which evidently are sprouts or second-growth from the stump of a still older tree. The individual stems in this group form very tall, clean trunks, as upright and tree-like in form as the best type of the eastern walnut. The other two trees in this group have single trunks at the base, growing up with clean, erect trunks and lofty, spreading tops. They resemble the first mentioned tree in most respects, save that one of them has deeply fur-

*Bulletin of the Southern California Academy of Science, Vol. 1, p. 23, 1908.

rowed bark much resembling that of *Juglans nigra.* All of these trees bear medium sized, almost perfectly smooth nuts, similar to those of the northern California black walnut trees found growing about the various towns mentioned above. It is evident at first sight that these

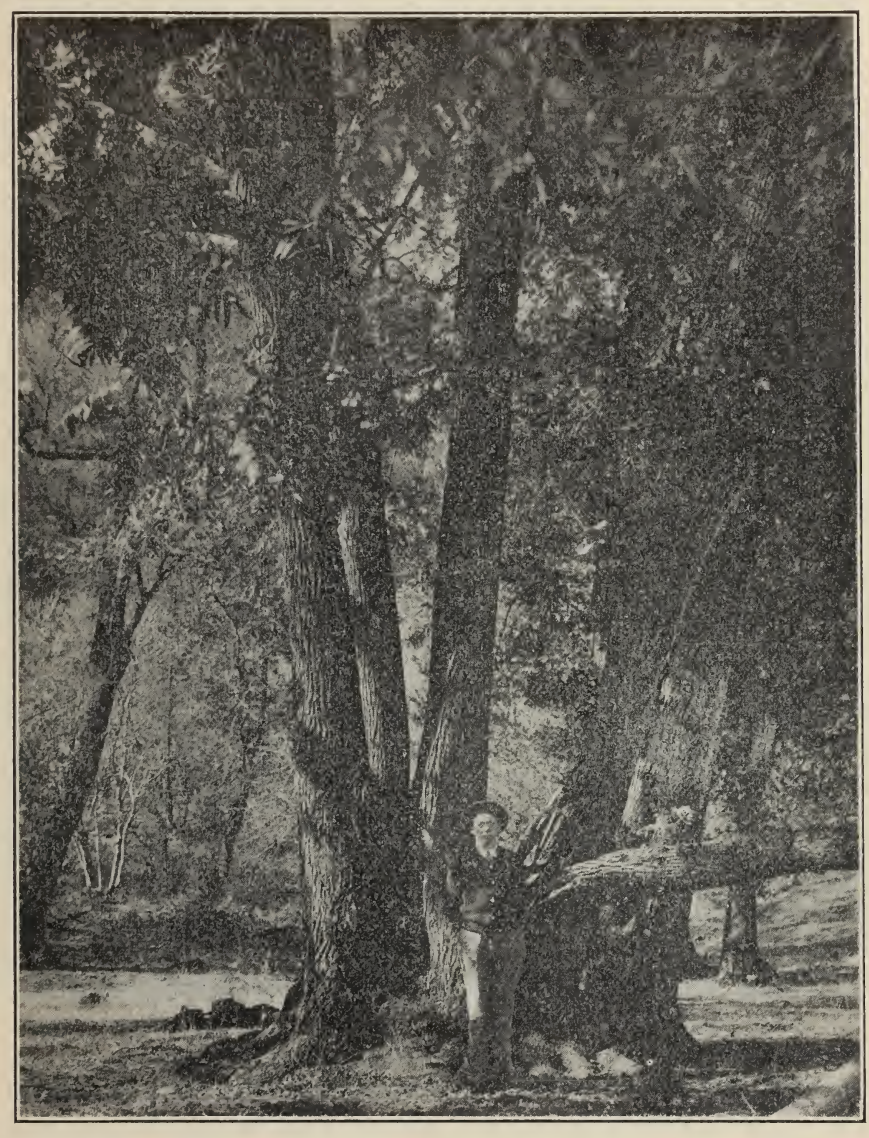


FIG. 5.—Old black walnut tree at Walnut Grove, Napa County.

are very old and on the decline. They are gradually dying all over the tops and large limbs are breaking off and falling to the ground.

Around each of the other basins in the hillside is found a group of similar trees, some with single trunks, others composed of several stems

coming from a common base. Other trees are found in considerable numbers scattered here and there through the forest and about the hillside between the springy basins. Quite a number of these scattering trees have recently been cut for wood. Altogether there are several hundred of the trees. Evidently they have seeded spontaneously from the older ones and become distributed over an area of about a square mile by natural means. The impression gained at present, however, from all these trees, is that they are no longer reproducing to any extent, but are gradually dying out. There is hardly a specimen less than at least twenty years of age, or possibly fifty years might be nearer the truth. All the older trees are dying back and breaking down and show very little vigorous, new development. The latter is seen only in the case of those trees which have been cut down during the last two or three years. In these cases a very vigorous crop of sprouts has been sent up from each stump.

Examination of the stumps of some of these cut-off trees shows one that many of them were more than one hundred years of age when cut, and this is true even of some of the smaller ones. Some may be found which are considerably older than this and apparently well up toward two hundred years old. The broken off stem shown in the picture of the largest tree was cut off and found to be at least sixty years of age, and probably considerably older than this at the base. This was much the smallest of the trunks in this group.

The little glade in which this tree stands was evidently the site of an Indian village, as evidenced by numerous arrow heads, spear points, mortars, etc., which have been found there. On investigation these trees show beyond all possible doubt that many of them must have been large, old trees even at the time of the Spanish occupation of California, and that they could not have been planted by any white people. This grove can be most readily reached by driving from Napa to Wilson's Inn, a summer resort, at which is located Atlas post office, and from which a wood road leads down to the walnut trees at a distance of about two miles.

A few miles southeast of this grove, on the old Combs ranch in Gordon Valley, there stand several black walnut trees, one of which is particularly large; early settlers state that this tree existed from their earliest recollection, but that they can remember it as a comparatively small tree. It is, therefore, probably older than any of the trees planted about the towns during the past sixty years, but younger than those upon the mountain-side, from which it presumably descended. One of the oldest residents of this region, Mr. Joe Gordon, of Gordon Valley, was interviewed in regard to the history of these trees. Mr. Gordon is of Spanish descent and was born and has always lived in this vicin-

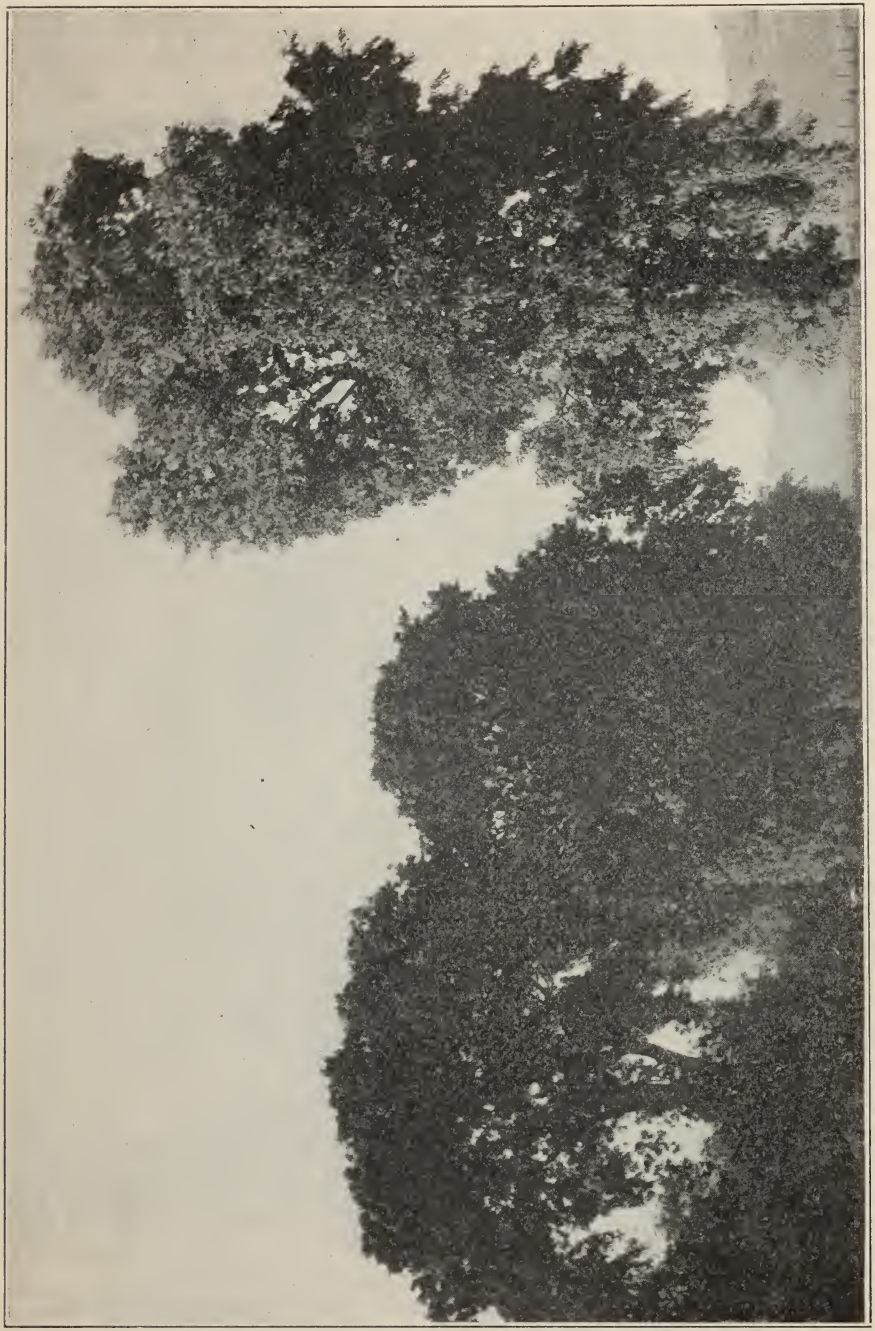


FIG. 6.—Native black walnut tree, Moraga Valley, Contra Costa County.

ity, being now a man of advanced age. Mr. Gordon stated that the one tree just mentioned had existed as long as he could remember, but he could recollect it as a small tree in his boyhood. In the grove on the mountain-side, he stated, there were old trees as large as any which are there now as far back as he could remember in his earliest boyhood. Several of the earliest American settlers, whose memory goes back for nearly sixty years, make the same statement in regard to these trees.

The history of the two stations mentioned in the quotation from Jepson has been quite thoroughly investigated in connection with this work. In regard to the one mentioned near the base of Mount Diablo, we may say that in the valleys on the west side of the mountain in the vicinity of the towns of Walnut Creek, Danville, Lafayette and Concord, there are a great many California black walnut trees, both young and old, most of which have been planted within the memory of people still living in that vicinity. Inquiry shows, however, that there was one locality in this region where black walnut trees were growing when the first white people arrived in the country. This is evidenced by the memory of various old settlers, also by the name "Walnut Creek," and the fact that the original Spanish grant comprising this region bore the name "Rancho Arroyo de las Nueces y Bolbones." "This fact," to quote from Mr. Ely Hutchinson, "is confirmation strong as proofs of holy writ that the walnut was growing in the vicinity when the Mexicans sent in their petition for the grant." The name "Bolbones" appears to be at present quite obscure, but, according to the investigations of Mr. Hutchinson, it probably refers to some other kind of tree which grew in that vicinity. The original trees of this locality were located in the so-called "Moraga Valley" in the Walnut Creek country east of Oakland. Some of these trees are still standing, although many of the finest were cut for timber many years ago. These trees are of an extremely stately, tall-growing, clean-trunk type, fully as much so as the best types of the eastern walnut, *Juglans nigra*. They are all composed of single trunks and have the appearance of being younger than the oldest trees in the Napa Mountains. The bases of them are larger than any of the trees in the latter locality, being in good, moist, deep soil in an open valley, free from the competition of other trees. The nuts and foliage are entirely similar to those of the Napa County trees.

The third original locality mentioned is that in the vicinity of the town of Walnut Grove on the Sacramento River, about thirty miles south of Sacramento city. Large, old, black walnut trees are very abundant on the ranches in this locality, and there was until quite recently a long row of large, fine, old trees along the river bank outside the levee from Walnut Grove north. These trees were cut down

a few years ago in repairing the levee. Although very large, they were not the original trees of that locality, but were planted there within comparatively recent times. Inquiry in the vicinity of Walnut Grove has developed the information that when the first American settlers came to the lower Sacramento there were a great many black walnut trees growing in this vicinity. Mr. William Holtlum, who at the time of this investigation was thought to be about the oldest living settler in the vicinity of Walnut Grove, came there about 1850. At that time, he stated, there was quite a large grove of magnificent black walnut trees growing at and below the fork of the river just below Walnut Grove. There were twenty or more trees there over three feet in diameter. Black walnut trees were scattered all along the river from Freeport to Rio Vista, growing on the higher spots on the river bank rather than in the more swampy land further back from the river.

On what is now the Hart place, near Isleton, there were some especially large trees. The row of trees which stood along the river near Walnut Grove was planted by one H. W. O'Dell. The earliest planting was probably about 1856, followed by others up to the early sixties. During the early fifties many people used to come to Walnut Grove from the country about Vacaville, Elmira, and other places, and carried away walnuts by the bushel and sack. Up and down the river there was a great growth of live oak, white oak, ash, cottonwood and black walnut until 1856, when a great fire from the north swept over the whole country destroying almost all the native timber. . . Mrs. Clara Lord, of Walnut Grove, stated that her parents came to this locality in 1850 and set up a tent under three walnut trees which stood in front of her present house. There were also many other large black walnut trees in the locality at that time. . . Mr. Joe Wise stated that he chopped wood on the river in 1853 and '54, and chopped down many walnut trees 2½ feet and more in diameter. . . Mr. Robert Sharp, of Walnut Grove, stated that he came to the vicinity in 1851, when a boy, but remembers very distinctly that there were many large walnut trees growing along the river at that time. Also that they had to cut their way in with axes on account of the luxurious vegetation. . . Mr. Joe Greene, living two miles above Courtland, stated that in the early days they cut out black walnut trees two, three and four feet in diameter. Also that such trees grew among the timber along the river bank rather than back in the swamps, and that they extended south as far as Rio Vista. . . Mr. C. V. Talmage came to this region in 1857, and stated that there were many immense black walnut trees along the river at that time. He has trees on his place of immense size, which were planted in 1858. . .

This data is sufficient to show that there was an abundant growth

of black walnut trees at this point previous to the first white settlement. Apparently, none of the original trees now remain in this locality, although some of the largest black walnut trees in the State may be found here, having been planted in the fifties. These trees and the nuts which they bear are of exactly the same type as those at Walnut Creek and at Walnut Grove in the Napa Mountains.

It is not improbable that other localities of this sort may be found in the northern part of the State, especialy in northeastern Napa County where we have a fairly definite report of such original trees.

As to the oldest trees standing in the vicinity of the various towns mentioned, the history of almost all of them can be ascertained. In regard to the two large trees south of Gilroy, for instance, which are some of the largest in the State, Judge S. F. Leib, of San José, writes us as follows: "I was informed by Mr. Zuck (now deceased), who examined into the matter for me, that the two large native California black walnut trees about a half mile south of Gilroy fronting on the public road were planted in 1856 or 1857 by Mr. Reeve. I measured them last fall and found each of them to be over four feet in diameter." About San José there are trees still older than these, most or all of which appear to have been planted from nuts obtained at Walnut Creek. About Stockton most of the oldest trees seem to have come from Walnut Grove on the Sacramento River. In Suisun Valley there are some particularly large, fine old trees on the Matthew Wolfskill ranch and others, planted in the fifties. The nuts from which these trees grew came mostly from Walnut Creek. There are some very large trees on the Dan Berry place in the same vicinity. These are thought to have been planted in the early fifties from Walnut Creek nuts. In the vicinity of Vacaville there are numerous old trees; one on the W. B. Davis ranch east of Vacaville is said by Mr. Davis to have been a natural seedling in Gordon Valley, Napa County, which was moved to Vacaville in 1853. This is the largest tree on the place, standing just south of the Japanese bunk house. Mr. Davis states that he grew a nursery in 1860 from nuts obtained at Walnut Grove on the Sacramento River, and that most of the old trees about Vacaville came from this planting. When he obtained the nuts there were many trees at Walnut Grove three to four feet in diameter. On the Thurber place in Pleasant Valley, between Vacaville and Winters, there are two large trees in front of the house at the front gate and one north of the house which were grown by Mr. Hough on the Joe Bassford place. He got the nuts from Napa County, supposedly from wild trees. The long rows of black walnuts on both sides of the road near the Fred Buck place, most of which have been worked over into English walnuts, came from the Wolfskill place near Winters. On the latter places, that of

John Wolfskill east of the road and that of his brother on the west side, there are a great many old California black walnut trees, the oldest being a row along the creek bank to the northwest of the road. These trees, according to a statement of Mrs. S. Wolfskill, were planted about 1855 by a man named McMahan, from nuts obtained in the mountains east of Napa. (Presumably from the trees which we have described.) Mrs. Wolfskill states that all the black walnut trees in this vicinity originated from this planting. According to the recollection of her sons, Joe and Will, however, John Wolfskill brought walnuts from the Sacramento River about 1860 and planted them on the ranch. Mr. W. W. Smith, of Vacaville, recollects that a man by the name of Percy Wiggins, who formerly lived in Napa, told him that he found walnuts growing wild in Conn Valley in the northern part of Napa Valley, and planted a nursery of these about 1858. He sold all these trees but one and allowed this one to grow where it stood, which was in Browns Valley west of Napa. Mr. Smith took nuts from this tree in 1873 and raised the trees which stand along the road on what is now the Henry Bassford place near Vacaville, which trees were cut off and worked over to English walnuts after they were a foot or more in diameter.

We need not occupy our space with further details of this sort, having given enough of this historical matter to show that the origin of most of these old trees can be traced by inquiry among old settlers.

SOUTHERN CALIFORNIA TYPE.

In the southern part of the State black walnut trees, apparently indigenous, are found growing over a considerable area, and, contrary to the case in the northern part of the State, very few such trees have been planted out along roadsides or for ornament. The southernmost point at which the tree, to our knowledge, is found growing is in the Santiago Cañon east of the city of Orange. From this point north it occurs sparingly near the mouth of the Santa Ana Cañon, abundantly in Brea Cañon along the road between Fullerton and Pomona, and scattered through various cañons in the Puente hills west of this road. It is quite abundant in the San José hills west of Pomona, especially in the so-called Walnut Wash, which extends down toward Covina. The species is scattered sparingly along the southern base of the high mountains from the Cajon Pass above San Bernardino to Garvanza, near Los Angeles. In the Santa Monica Mountains the tree is abundant, especially on the northern slopes, near Lankershim, near the north opening of the Cajuenga Pass, and in all cañons through this range on

both sides to its northern extremity near Hueneme. The tree is abundant along both branches of the Southern Pacific Railroad between Burbank and Ventura and in the intervening country. That is to say, it occurs in the vicinity of Chatsworth, Simi, and Moorpark, in the hills north of the latter places, in the next valley north near Newhall and on down the valley through Camulos, Fillmore and Santa Paula, and in the foothills to the north of this valley (Santa Clara Valley of the

Fig. 7.—Native southern California black walnuts, Brea Cañon.

south). Going farther north, the tree is not seen near the railroad, but is abundant in the foothills up into the Ojai Valley back of Ventura, and scattered along the foothill range back of Ventura and Carpinteria, north of which point near Santa Barbara the species begins to grow scarce. Mr. C. W. Beers states that Mr. Ellwood Cooper has pointed out to him trees which were undoubtedly growing wild in the cañons back of Mr. Cooper's ranch some twenty miles north of Santa Barbara. From this point north we know of no well authenticated

record of native-growing black walnut trees until we reach those at Walnut Creek near Mount Diablo, a distance of about three hundred and fifty miles. We have investigated various reports of indigenous trees in this stretch of country, but thus far have found evidence of all such having been planted since the American occupation.

The southern California trees are considerably different in aspect from those of the north, although individual specimens of each may be

FIG. 8.—Large southern California black walnut tree near roadside between Ventura and Nordhoff.

found which resemble each other quite closely. The southern tree is much more shrubby, frequently branching directly from the ground, and tending to break up into a much branched, broad, low-spreading head even when a single trunk is formed. It is not, as is popularly supposed, a dwarf or slow-growing tree, except in so far as it is influenced to develop in this way by the fact that it is able to and frequently

does grow upon dry, exposed hillsides rather than in deep, rich, moist soil, to which the original groves of the northern California type are confined. In a similar situation, the southern California tree grows rapidly and vigorously, forming particularly a very thick trunk, but with a round, bushy top rather than with a single, erect, continuous, central axis. Along the road between Ventura and Nordhoff and in the hills about the latter vicinity, trees of extremely great trunk diameter may be seen, but the tops are very broad, low and bushy. Professor Jepson has well characterized this form as "elephantine" in comparison to the erect, arboreous habit of the northern type. There is an immense tree of apparently the southern type on the premises of F. M. Gifford, at No. 18 East Haley street, Santa Barbara. This tree is of unknown age and over four feet in diameter. There is another extremely large one a few miles northwest of Covina, forming a well-known landmark and resting place by the roadside. Many other instances could be cited to show that the southern California black walnut is not at all a dwarf tree, but is rather one of rapid growth and large size in diameter when growing under conditions at all favorable.

The nut of the southern type varies considerably in size on different trees, but in general it is much smaller than that of the northern type.

Relationship Between the Southern and Northern California Types of Black Walnut.—Assuming that the southern California type of black walnut is indigenous to the region where it is found, which fact there is no reason to doubt, the question arises, whence came these three, isolated, original groups of the northern tree? It is most natural to agree with Dr. Jepson that these northern trees were planted by the Indians many years ago, either intentionally or by chance, with nuts which they had brought from the south for food and exchange. Each of the three localities is known to have been the site of an abundant Indian population, and it is also well known that walnuts and other nuts were carried about by the Indians for such purposes.

Mr. Joe Gordon, alluded to above, whose memory goes back to about 1846, states that in his youth, when Indians were abundant in Solano and Napa counties, they frequently used black walnuts with which to trade with the white people for various articles which they desired. On being questioned as to his idea of the origin of the old walnut trees in his vicinity, Mr. Gordon stated that he had heard that black walnuts grew wild in the southern part of the State and that his idea had been that the Indians brought nuts from the south from which these trees originated. The more erect type of tree and the larger nuts of the northern type are explained by Professor Jepson as an influence of environment.

In order to obtain further light upon this question, we commenced

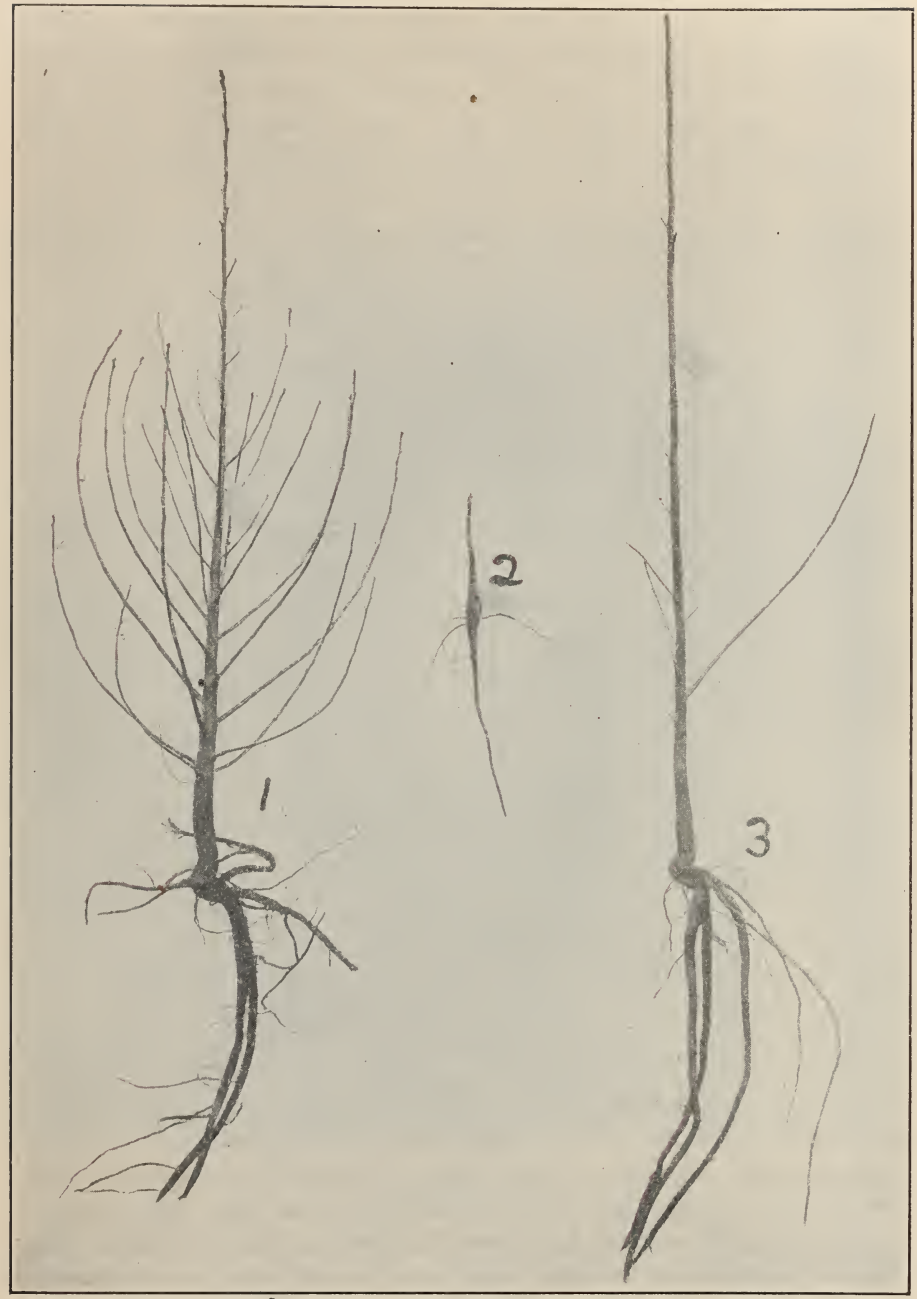


FIG. 9.—One-year-old black walnut seedlings; southern California on the left (1), eastern in the center (2), northern California on the right (3).

several years ago planting both southern and northern California walnuts side by side in nurseries both in the south and in the north. When so grown the resulting trees have shown very marked and constant differences from one another and the characteristics of each type as shown in the nursery have remained constant both in the south and in the north. Seedlings of the southern type are much more branching and bushy than those of the northern, sending out large, lateral branches and secondary stems close to the ground, while the northern seedlings grow erect with one stem and few large laterals. In this way the southern seedlings are broad, bushy and covered with foliage clear to the ground, in marked contrast to the other type. The leaves of the southern tree are somewhat smaller, more finely divided and with more sharply pointed leaflets than those of the northern. They are also a little lighter in color and the bark is of a brighter green. One of the most pronounced differences lies in the fact that the southern seedlings come out much earlier in the spring and continue to hold their foliage and grow much later in the fall than the northern, whether they are planted in the south or in the north. This is a most decided difference and holds true constantly, the rows of southern seedlings being always in full leaf in the spring while the northern are still bare, and showing the same condition in the fall for several weeks after the northern California seedlings have dropped all their leaves. This characteristic is one upon which environment, in the first generation at least, has no apparent effect. In the germination of the nuts the two forms also show a difference. Nuts of the southern California type are much quicker to germinate in the spring and when planted in the same conditions invariably sprout much earlier than the northern nuts, whether they be planted in the north or south.

Another decided difference lies in the relative effect upon trees of the two forms of various conditions such as dryness, heat, etc. An apparently physiological disease, which we will discuss later, called the "yellows" or "frizzles," affects the northern California type very badly in some instances, but we have never known a southern California seedling to show this disease, even though grown in rows adjoining badly-affected northern California trees. Another disease, nursery root rot, see page 379, invariably picks out the southern California black seedlings, never affecting those of the northern type in the same nursery.

We know of no trees of the southern California type of any considerable age now growing in the north. There are several of these trees about four years of age planted by Professor E. B. Babcock on the University grounds west of the new agricultural building, and these trees are of the characteristic bushy-topped form, coming out early in the spring and holding their foliage very late in the fall, in marked contrast to trees of the northern type. We have planted southern nuts in several nurseries in the northern part of the State and found that the resulting

FIG. 10.—Young northern California black walnut tree, State School grounds, Whittier.

seedlings retained all their usual characteristics in relation to seedlings from northern California nuts. No effect whatever of environment could be seen in any of these cases. Of the northern California walnuts in the southern part of the State, we know of one considerable planting

Fig. 11.—Young southern California black walnut tree, State School grounds, Whittier.

near Pasadena where the trees are now old enough to produce quite large crops of nuts. These trees retain all the characteristics of the northern California type in regard to the size of the nuts and the time of foliation and defoliation.

Considering the characteristic and constant difference in the form of the trees, both in old specimens and in the nursery, the most pronounced difference in the vegetative period when the trees are grown side by side, and the same difference under the same circumstances in relation to the diseases mentioned, we feel, on the whole, extremely doubtful as to the identity of the northern California type with that of the south. It seems to us certain that the northern type is at least a distinct variety of the southern, in which case Jepson's classification of it as *Juglans californica* var. *hindsii* would be acceptable. Still it is remarkable that a variety so uniformly distinct from the original type in the larger size of the nuts, the upright form of the tree, later foliation and earlier defoliation period, slower sprouting of the nuts and different behavior under certain climatic conditions should comprise all the northern California trees without exception. It is also remarkable that so distinct a variety should have developed in the north without the development of any other distinct varieties in the south or other portions of the State. Almost the only way to account for the northern California type as a variety of the southern is to assume that the northern trees are all descended originally from one individual tree, which tree happened to be of its distinct type.

We are considerably inclined toward another solution of the question, namely, that the northern California trees represent the relics of an almost extinct species, paralleling the case of several other trees found in California. In this case the northern California walnut would probably be called *Juglans hindsii* Jepson. Even under this supposition, it is true in all probability that the original trees of the northern type found in the three localities mentioned were planted by the Indians rather than representing an original, indigenous growth. What, then, the history of the tree was previous to these plantings and when the original planting in these localities took place must still remain a mystery. Present indications are that the Napa County station is the oldest of the three, and it is possible that the tree was originally a native of that portion of the State whence the nuts were carried by Indians to other localities.

OTHER NATIVE WALNUTS OF THE SOUTHWEST.

In addition to the California species of black walnut, there have been more or less distinctly recognized by botanists at least two other species, namely *Juglans rupestris* and *Juglans major*, the range of these forms extending over Arizona, New Mexico, and Texas. Much uncertainty has prevailed and still exists as to the identity and limits of these species, especially as to the limitations of *Juglans rupestris*. By some

the latter species has been held to include, at least as a variety, the southern California type, while *Juglans major* has frequently been considered a variety of *rupestris.* The general understanding of *rupestris* has been that it is a decidedly dwarf, shrubby type with very small nuts, while *major* has been considered a larger and more erect form. According to Britton, *Juglans major* is the species indigenous to Arizona, particularly the western portion, while the range of *rupestris* is found further eastward in New Mexico and Texas. We have not studied this subject to any extent from a botanical standpoint, but in connection with our investigations on rootstocks for the English walnut we have received and planted nuts from all the states just mentioned, and have also through correspondence gathered considerable information concerning the native black walnuts of these states. From such information, together with a study of the nuts which we have received and the trees grown therefrom, we are convinced on one point, namely that *Juglans major* of western Arizona and *Juglans rupestris* of New Mexico and Texas are quite distinct from one another and also distinct from either of the California types. It is true that all four of these forms run more or less into one another, and the question as to whether the differences between them are of varietal or specific rank does not lie within the province of the present work. It is certain, however, that in the nursery the four forms are very distinct and decidedly different from one another. From our observations thus far it would appear that there is as much similarity between *Juglans major* of Arizona and *Juglans hindsii* of northern California as between any other two of the four types. Our observations in this respect, however, extend only to the general form and appearance of the old trees, seedlings, and nuts.

NATIVE WALNUTS OF ARIZONA.

Black walnut trees of an evidently indigenous nature are found growing in various portions of Arizona. The Arizona species was formerly classified as *Juglans rupestris,* with a variety or second species called *Juglans major,* the latter being supposedly a more erect and tree-like type than the true *rupestris.* Professor J. J. Thornber of the University of Arizona writes as follows:

"We had supposed that *Juglans rupestris* was our common walnut here and had classified it as such. Last year, however, I came to the conclusion that our species, at least a considerable amount of it, is *Juglans major.* This is our common walnut that grows in southern Arizona, and it may be the only species. *Juglans rupestris,* as I understand it, grows in Texas, though of course it may get as far as Arizona." Again, "I am sending you under separate cover two quarts of nuts of

Juglans major, as we call it. The plant may be only a form of *Juglans rupestris.*" Again, "The tree (*Juglans major*) is common throughout southern Arizona, in mountain cañons and alluvial soils of flood plains. It grows at as low an altitude here as 1,500 feet and apparently as high in the mountains as 8,000 feet, so you see it has a wide range."

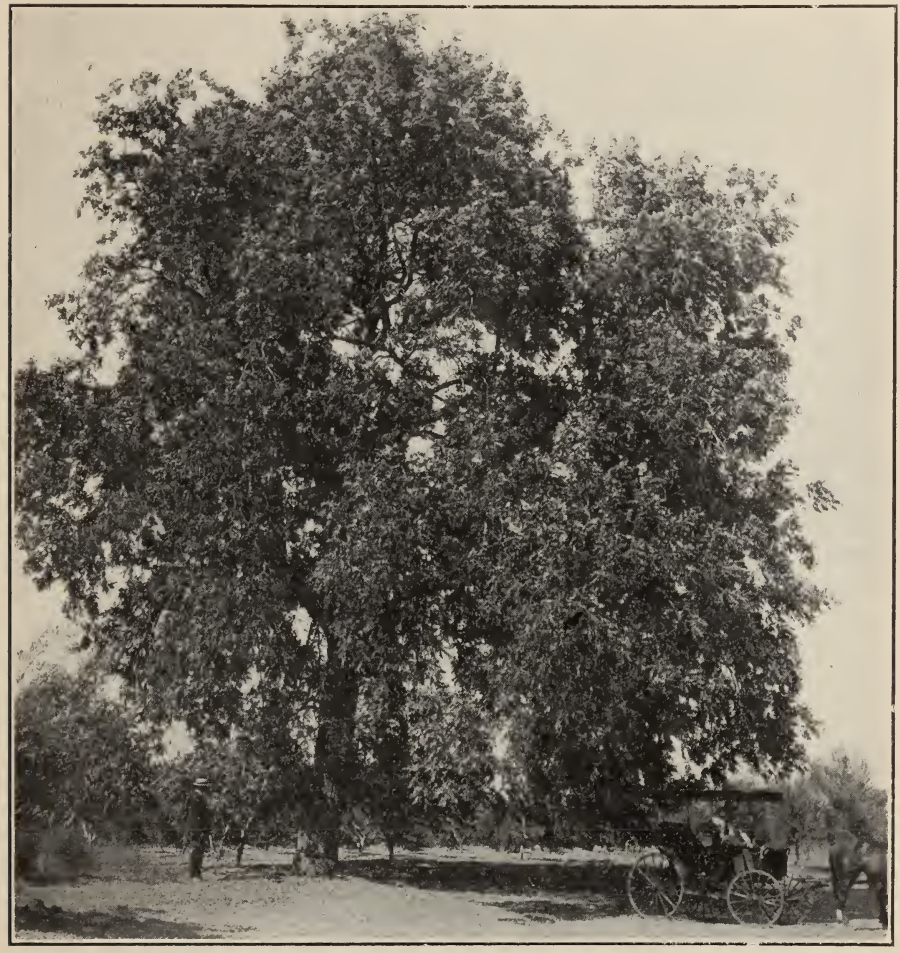


FIG. 12.—Arizona black walnut tree, Vacaville.

One old tree which we found growing in California, of supposedly Arizona origin, is of interest in this connection. This is located on the home place of Mr. Harbison, near Vacaville, and is a very large, erect tree said to have been planted about 1854. The story is that Mr. Harbison's father crossed the plains in that year and picked up some walnuts in Arizona, from one of which this tree came. The tree is of a decidedly erect, tree-like type with none of the dwarf or bush form

which is supposed to belong to *Juglans rupestris*. It is much like the northern California black walnut in general appearance, but the nuts are somewhat smaller and more deeply grooved and the aspect of the foliage slightly different. Seedlings from this tree, and likewise those grown from Arizona nuts, are in general appearance very much like the northern California type, being of a rapid growth, erect, with dark-colored bark and no large side branches. The tree is decidedly different in the nursery from the supposedly true *Juglans rupestris* of Texas and New Mexico and it is therefore our conclusion that *Juglans major* is a fairly distinct species as southwestern black walnuts go.

NATIVE WALNUTS OF TEXAS.

From Texas we have received many nuts of what we take to be the true *Juglans rupestris*. These nuts, while varying greatly in size, are smaller even than those of the southern California type, while some of them are extremely tiny, averaging only about one half inch in diameter. The nuts are characteristically marked by decidedly deep, branching grooves, being easily distinguished in this respect from the California species and from *Juglans major* of Arizona. As compared with nuts of *Juglans nigra* these are much smaller in size, less abundantly grooved and not ridged like those of the latter species. From such nuts develop what appears to be true *Juglans rupestris*, a dwarf, shrub-like tree, of comparatively slow growth even in good soil. These trees have a light-grey bark, lighter in color than that of any other black walnuts. In seedlings the bark toward the base of the tree is of this light-grey color, prominently striped with still lighter markings, while toward the tops the bark is of a characteristic, light, yellowish green. The seedlings which we have raised have usually produced the first year only a single stem with no side branches, which stem leans decidedly to one side rather than standing up perpendicular to the ground. Our trees have become rather bushy in later years but have continued with a single main stem, slow growth and a leaning position. The foliage is composed of leaves with rather narrow leaflets and a lighter or more bluish green than those of other species. The type is decidedly different from anything else which we have grown and its seedlings are entirely distinct from those of the Arizona *Juglans major*, which are rapid-growing, erect, with dark-colored, almost black bark.

In various lots of nuts received from Texas great variation has been found in respect to size and degree of roughness. Some of the nuts were of the diminutive size and characteristically deep-grooved type described above, while others were larger and so much grooved as to be indistinguishable from small nuts of *Juglans nigra*. So far as we

have raised trees from any of these nuts, however, they have all been quite characteristic of the *rupestris* type described above. The range of *Juglans nigra* extends westward into Texas so that it would not be surprising to find hybrids and peculiar forms there, if the various species hybridize as readily in that locality as they do in California. Mr. G. A. Schattenberg, of Boerne, Texas, writes as follows:

"While I have not sufficiently investigated the matter, I have seen enough to convince me that there are more than two very distinct forms here. As with the pecan, hardly two trees can be found with nuts alike. We collected over twenty-five bushels of nuts the past season and found hardly two trees alike."

Mr. F. T. Ramsey, of Austin, Texas, another of our correspondents, writes as follows:

"I will try to find you some of the small walnuts and mail them. I do not believe that this particular walnut has been definitely mentioned by any botanist. The trees rarely have any top of any consequence, but are inclined to throw up two or more branches near the ground. They are sometimes nothing better than a big bush. In their wild state they are usually found along the river banks and gravelly streams in the limestone country running west from Austin. Lampassas is 70 miles from here, yet the nuts up there seem to be five or six times as large as the nuts here. However, some trees here bear larger nuts. There is infinite variation in the shape and size of both nuts and trees, also in the time of ripening, which varies from the first of August to November. Irrigation and good cultivation makes them no larger. They are enormous bearers of pollen. There are a few eastern black walnuts growing through this country. Upon the steep sides and valleys of our rough rocky cedar mountains we have a walnut that makes a large tree, but bears a nut in size just between the *rupestris* and the black. The intermedia has a light green leaf free from yellow tinge and grows slower than *rupestris*."

NATIVE WALNUTS OF NEW MEXICO.

Through correspondence we have obtained some information as to native walnuts in New Mexico, and also have planted a considerable number of nuts from that State. Professor E. O. Wooton, of the New Mexico College of Agriculture, writes as follows: "I am sending you specimens of two kinds of black walnuts obtained from this region. Both kinds are obtained from relatively large trees which grow in the Mogollon mountain region of this territory. Neither is *Juglans rupestris*; just what they may be I am unable to say. I have seen *Juglans rupestris* growing and know to a certainty that the trees from which these nuts came are not of that species."

Mr. James K. Metcalfe, of Silver City, New Mexico, from whom we obtained large and small types of walnuts, native to his locality, writes: "We have always considered that trees which bear the larger nuts are simply those which grow nearer water." Subsequent to Mr. Metcalfe's death, his daughter, Miss Mary Metcalfe, writes: "The trees grow to fair size and then are invariably hollow. They are beautiful landscape trees. 30 to 35 feet in height, diameter 2½ feet or a little more. Grow best where they can get down to water."

These New Mexico walnuts vary largely in size and roughness similarly to those from Texas. All the trees which we have grown from them have been of the *rupestris* type with light-grey bark, but varying considerably in size and rapidity of growth. Some of them appear at present as though they might make trees of considerable size, while others bid fair to remain quite small like typical *rupestris*. We have received nothing from either Texas or New Mexico which at all resembles the typical *Juglans major* received from western Arizona. There is a tree in the Botanical Gardens at Berkeley, on the east side of the walk running across the upper end of the garden to the Mechanics' Building, which was formerly labeled *Juglans rupestris,* and which appears to be typical of this species as we have grown it in the nursery. This tree has a single trunk and axis, but is of small size and slow growth, with the typical light-grey bark, light-colored foliage and leaning position.

OTHER AMERICAN SPECIES.

THE BUTTERNUT.

(Juglans cinerea).

This well known native nut of the Northeastern United States is not native to California, although a number of specimen trees are to be found in the State, especially on some of the older ranches. There are trees in bearing on the John Wolfskill ranch at Winters, Matthew Wolfskill's in Suisun Valley, George Payne has a tree near San José, and there is one in Berkeley on Allston Way, just across from the University cottages, on the lot which corners on the west side of Oxford street. This species is easily identified by its long pointed nuts, the surface of which is covered with high, rough, sharp ridges. It is a tree of slow growth and of no economic importance in California.

FOREIGN WALNUT SPECIES.

There is, as stated in our quotation from Professor Sargent's work on page 171, a considerable number of native walnut species in various parts of the world. Of these, the following are of some importance in California:

Juglans sieboldiana Maxim.—This forms a good sized tree, bearing nuts in long clusters or racemes with sometimes as many as twenty in a cluster. The nuts are very hard shelled, rather long and pointed, with a fairly smooth surface. The best and oldest specimen of this tree in California is one at the Tower House in Shasta County, on the road between Redding and Weaverville. This tree was planted about 1860, and is now a large, fine specimen, bearing heavy crops of nuts every year. Another bearing tree may be seen on the grounds of the old Experiment Station near Pomona, and there are probably others in the State. The species is a native of the mountains of northern Japan and is hardy, vigorous and of rapid growth. It is at present of no economic importance in this State.

Juglans cordiformis Maxim.—A Japanese species considerably like the last, trees of which are sometimes offered by nurserymen. There appears to be some doubt whether this is more than a variety of *Juglans sieboldiana,* differing in the shape of the nut, which is heart-shaped, flattened and pointed at one end, with a shallow groove in the middle of the flat sides.

Juglans mandshurica.—A species sometimes offered by nurserymen, originating in Manchuria. Said by some to be simply a variety of the English walnut.

Juglans boliviensis.—A species supposedly native of Bolivia, which is said to form forests of fine, large, vigorous growing trees in that country. This form has been secured by Mr. Frank A. Leib, of San José, from whom we have received scions and produced young trees of this species.

Pterocarya caucasica.—We have obtained scions of this species, which is supposed to be the Caucasian walnut of commerce, from Mr. George Payne, of San José, who raised trees from seed. The seed is very small and not at all like that of ordinary walnuts.

HYBRID WALNUTS.

The readiness with which different species of *Juglans* hybridize or cross with one another is quite remarkable. To such an extent does crossing of this sort take place in California wherever two species grow anywhere near each other, that hybrid trees are extremely common in every part of the State under such conditions. In the vicinity of most of the northern towns, like San José, Stockton, Santa Rosa, Napa, Vaca-

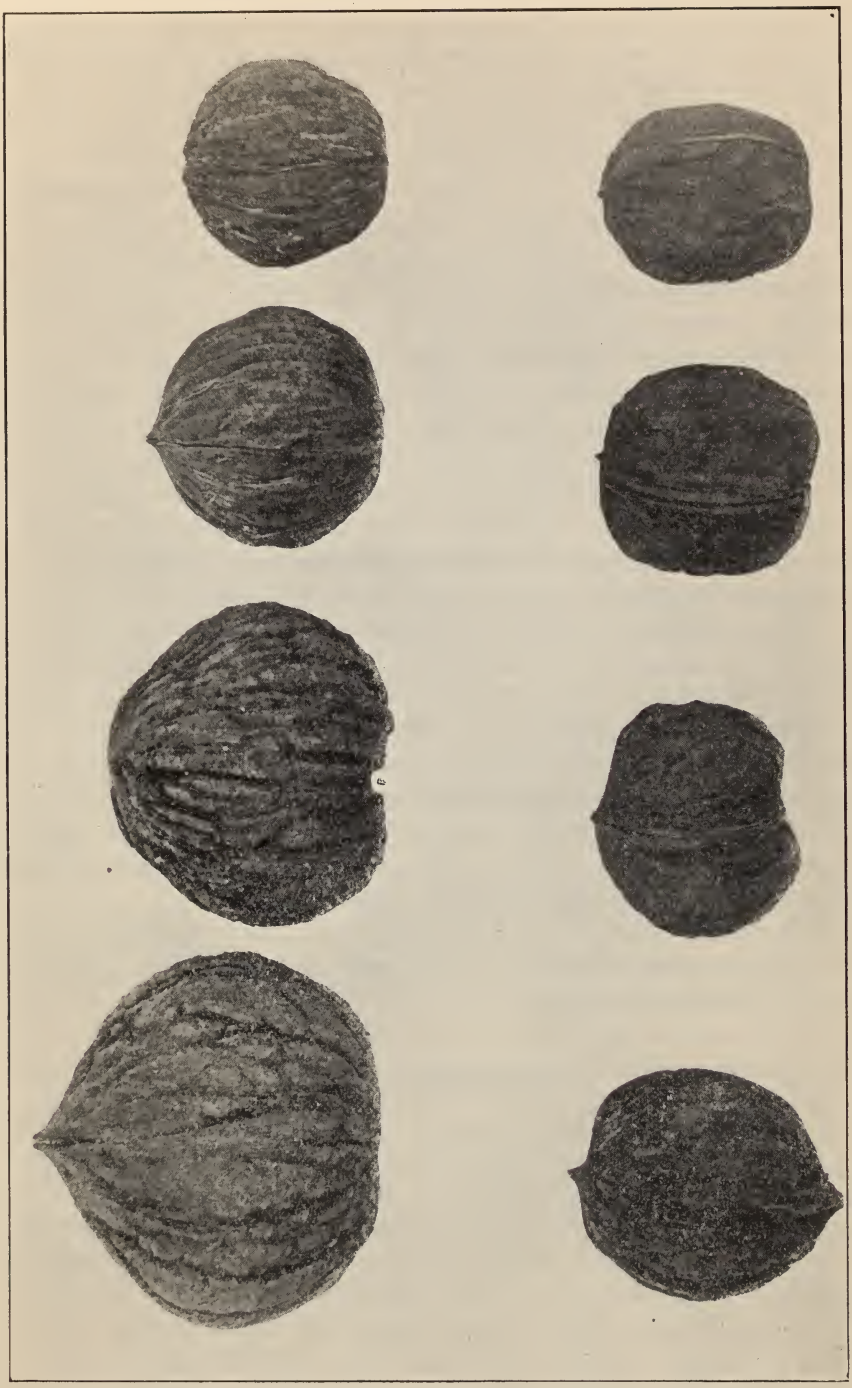


FIG. 13.—Nuts of hybrid walnuts, each from a different tree. Natural size. Royal in left-hand row, Paradox in right-hand row. Second nut from bottom in left-hand row is Burbank Royal.

ville, Winters, Chico, and almost all the other towns of this portion of the State, the northern California black walnut and the eastern black, *Juglans nigra,* have been very commonly planted during the last sixty years. The original specimens of *nigra* came from nuts brought from the East and Middle West, and such trees are typical in every way of their species. Among the younger trees, however, of later generations which grew from nuts obtained from these eastern and California trees growing more or less near together, numerous hybrids may be found, and indeed after two or three generations in California it is almost impossible to find a true type of *Juglans nigra.*

Another very common cross is that between various species of black walnut and the English walnut, which cross with great frequency in California wherever the species grow at all close together. These two crosses, that of California black on eastern black and California black on English, received considerable prominence several years ago through the introduction by Luther Burbank of trees of these two types, to which he gave the names respectively of Royal and Paradox. These names, in the absence of any others, have been quite generally taken up in California to designate trees resulting from crosses of this sort, so that now by the name Paradox is generally understood any hybrid tree resulting from a cross between English and black walnuts, while Royal means popularly any hybrid resulting from a cross between two different species of black walnut. Trees of both of these crosses, and all sorts of mixtures and degrees between four or five different species of *Juglans,* are not uncommon in the State, and the particular strains introduced by Mr. Burbank are simply two very good examples of hybrids which have likewise originated spontaneously in various parts of the State.

That these trees are true hybrids and not simply variations due to environment or other factors is evidenced in many ways, as may be seen in the following discussion.

PARADOX HYBRIDS.

If the nuts from a black walnut tree of any species which stands near an English walnut tree or grove be planted, the resulting seedlings are apt to show a varying percentage of individuals of decidedly different appearance from those of the black walnut. This difference consists in a more or less marked resemblance to English walnut seedlings, the trees having bark and leaves much resembling those of the English walnut, and, in general, a very similar aspect to the latter species. In their first year these seedlings may or may not differ decidedly in rate of growth from the straight black walnut seedlings, but after the first year in almost every case they show a more rapid development and within the first four or five years they assume a size and rapidity of growth several

times as great as that of the other seedlings. The rapid growth of some of these hybrid trees is truly astonishing. To such a tree which he obtained in Santa Rosa Mr. Burbank gave the name Paradox, and, as we have said, similar types are of common occurrence in almost every lot of black seedlings originating from a tree near which an English walnut stands.

The cross takes place just as freely in the opposite direction, so that if the nuts from the English walnut tree be planted, hybrids are likewise present among the seedlings from such nuts. In this case, however, it is much more difficult to distinguish the hybrids from the true English seedlings, inasmuch as there is much less difference in their appearance, particularly during the first year. In after years the hybrids begin to outstrip the others in rapidity of growth and differ from them in their general appearance. Such trees are sometimes found in seedling walnut groves, and become very conspicuous by their great size as compared with the other trees of the grove.

There is no noticeable difference in appearance between Paradox trees grown from black walnuts and those grown from English walnuts. Such trees are very slow in coming into bearing and in the majority of instances are always very light producers of nuts. Many of the trees bear enormous crops of catkins and pollen and many of them also produce very numerous pistillate blossoms, but for some reason the latter do not seem to pollenize readily and very few nuts result. The nuts vary considerably in different trees, but all that we have ever seen are intermediate in form between the black and English walnuts, extremely hard shelled and of no value whatever for eating purposes. There are a few Paradox trees in the State which some years bear quite abundant crops of nuts, but these in every case stand in close proximity to English walnut trees, and it is possible that most of their nuts are pollenized by pollen from the other trees. In the majority of instances, even though the hybrid trees stand in the midst of walnut groves where they were planted for English walnut trees and bloom at about the same time as the other trees, they set very few nuts.

The extent to which crossing takes place between the English walnut and various black walnut species varies with the nearness of the trees to one another and also, in a general way, with the degree to which the blooming time of the trees coincides. The percentage of hybrids from certain trees, however, varies decidedly in different seasons. Some years the nuts from a certain black walnut tree which stands near English walnuts will give almost all hybrids, while in other years the seedlings from the same tree will be almost all straight blacks. This difference is presumably accounted for by variation in the blooming time of the tree from year to year. Many trees give commonly as high as 40 or 50 per

FIG. 14.—Paradox hybrid walnut five years old from the seed; four years in present location.

cent hybrids, and seedlings from certain trees will some years run above 90 per cent.

We have observed Paradox trees resulting from the following crosses:

English x Northern California Black.
English x Southern California Black.
English x *Juglans nigra.*
English x *Juglans major.*
Also English x Paradox and English x Royal.

Trees of the first cross mentioned are found very commonly in certain nurseries where the northern California species has been planted. Also many trees grow in the northern part of the State among those which have been planted for northern California black and also those which have been planted for English. The so-called Smith tree near Elk Grove is an example of the latter. This particular tree bears a much larger nut than most Paradox walnuts. There are few trees of the cross in this direction in the State, simply from the fact that very few seedling walnut groves have been planted in the northern part of California.

Paradox trees grown from northern black nuts are very common. Most notable is that called the Yuba City tree, which stands in the town of the above name just across the street to the north of the court house. This tree is undoubtedly the largest walnut tree in California, and, in all probability, the largest in the world. Its great size is accounted for by its age, as it appears to have been planted at least forty years ago along with several neighboring ordinary black walnuts of the northern California type. Any one interested in walnuts will be well repaid by a visit to Yuba City for the purpose of seeing this grand tree. It is conspicuous long before reaching the town, rearing its enormous head above every other object in the whole vicinity. The tree bears a considerable quantity of nuts every year, but the amount of the crop is insignificant in proportion to the size of the tree.

Other Paradox trees occur in almost all the northern California towns and may be distinguished by their great rapidity of growth, very thrifty and vigorous appearance, foliage and general aspect closely resembling that of the English walnut, and very light production of inferior, very hard-shelled nuts.

Paradox trees resulting from the cross between the English and the southern California black are quite frequent in the south. In this case almost all the older trees resulted from the planting of the English walnut, as very few of the southern California black walnuts have ever been planted except in nurseries. In the latter case hybrids coming from the nuts of the black walnut are very common. In many of the seedling walnut orchards of the southern part of the State hybrids of the English and southern black have occurred. Frequently several trees of

this sort would develop in one orchard. These trees soon attract attention by their rapidity of growth, great vigor, and failure to produce nuts. Many of them have been dug out or grafted over as soon as their true nature became apparent. The Killian tree east of El Monte was a notable example of this type, growing in a seedling grove on somewhat sandy land, and one which had been considerably neglected during its earlier years. Under such conditions the trees suffered for water so that they were small and poorly developed for their age. This one tree, how-

FIG. 15.—Two Paradox hybrid walnuts in English walnut grove south of El Monte.

ever, was an enormous, thrifty, vigorous tree, several times as large as any of the others, but producing only a very few nuts and these of no value. The tree has now been grafted over to an English walnut variety.

In another orchard southwest of El Monte, on the road from that place to Whittier, may be seen two very large Paradox trees standing in a walnut grove upon decidedly wet land, where the regular English walnut trees are small and in poor condition. The Paradox trees are several times larger than the others and in a very thrifty, healthy condition. These hybrid trees, therefore, resist both drouth and excess of water

much better than does the English walnut, growing vigorously under extreme conditions of both sorts.

In our experimental orchard on the state school grounds at Whittier there is a tree of the southern California species which was planted in 1907 along with the other trees. This tree is the first in the grove to come out in the spring, and all the English walnut trees immediately around it are French varieties, which do not come out for at least two months after this black walnut tree is past its blooming period. In

Fig. 16.—Camulos tree; Paradox. (Photo by Prof. W. T. Clarke.)

the farther end of the orchard to the west, some five or six hundred feet away, there are several trees of southern California English walnut varieties, some of which produce pollen nearly as early as does this black walnut tree. This tree in the spring of 1910, when four years old from the nut, set a crop of several hundred nuts, over 90 per cent of which when planted the following year produced Paradox hybrids of an extremely vigorous type. In 1911 the tree produced a much larger crop of nuts. It would appear in this case that the crossing with English pollen, probably mostly from the Chase variety, increased the

productiveness of the tree to a marked extent as well as producing such a large proportion of hybrids.

We will present but one other example of this cross, namely, the Camulos tree on the old Camulos or Del Valle ranch situated close to Camulos station, in Ventura County, on the Southern Pacific Railroad. This tree stands in a grove of old English walnut seedlings, and evidently resulted from a chance cross with wild black walnut pollen on the original tree whose nuts were used for growing the trees for this orchard. This is a very large, spreading tree, and is notable in producing much larger crops of nuts than any other Paradox tree which we have found. This tree, for some reason, either on account of inherent productiveness or crossing with the English walnut trees about it, seems to produce every year a very large crop of nuts. It is rather doubtful whether crossing with the other trees does take place extensively, as these seedlings are very uniform and typical second-generation Paradox trees rather than showing any indication of crossing. We had at one time great hopes of this stock as a root for the English walnut, on account of the productiveness of the tree and the fact that its seedlings are of a very uniform type. Unfortunately, however, like all other Paradox trees which we have tried, its seedlings have failed to justify this hope and do not impart any exceptional vigor to English walnut trees grafted upon them.

The Strong tree, on the ranch of Mrs. H. W. R. Strong, near Whittier, is a notable example of this cross in the opposite direction, the tree having been planted for a southern California black walnut. This tree is thought to have been planted somewhere about thirty-five years ago and was one of several supposed southern California black seedlings brought from Orange County. It closely resembles at first sight the black walnut type, especially in the foliage, but at the same time the leaf and particularly the bark show the English cross. The nut is very similar to the southern California black walnut. The tree is now of immense size, especially in the spread of branches, which extend far out with the lower ones coming down and resting upon the ground. The tree is comparatively a very light producer, but it is evident that some years it is crossed quite freely by the neighboring English walnut trees, and a large proportion of its seedlings have the appearance of first cross Paradox trees. The original tree is apparently a Paradox which partakes much more of the characteristics of the black walnut (the female parent) than of those of the English.

Paradox trees resulting from a cross of the English on the eastern black walnut, *Juglans nigra,* are comparatively uncommon, or at any rate there are few trees in the State which can be traced positively to this parentage. On the old Pleasants ranch in Pleasants Valley,

between Vacaville and Winters, there is a large Paradox tree in the dooryard near the corral which is probably of this cross. It is a particularly thrifty, beautiful tree, bearing fair crops of medium-sized nuts of the usual Paradox type. In the vicinity of Goleta, in Santa Barbara County, there is a considerable number of *nigra* trees planted along the road on the county road from Santa Barbara to Goleta. Intermixed with these *nigra* trees are numerous individuals of the southern California black species, while on either side of the road are extensive groves of English walnuts. In this instance a general mixing takes place and among the seedlings of the various trees may be found all sorts of freaks and hybrids. Nuts from the *nigra* trees give a majority of straight *nigra* seedlings, some of the Royal type (having crossed with the California black), and a considerable proportion of strong, lusty individuals of the Paradox type, as shown by their leaves which closely resemble those of the English walnut. *Nigra* trees come out so much later in the spring than most of our English walnut trees that it is remarkable that any cross takes place between these species. Apparently, however, the English pollen either retains its vitality for several weeks or there are some very late catkins which coincide in development with the bloom of the *nigra* trees. These *nigra* Paradox trees obtained from the Goleta nuts appear to be of an especially thrifty, vigorous, hardy nature.

The large old *Juglans major,* or Arizona black walnut tree, which we have described as standing on the Harbison ranch near Vacaville, crosses freely with English walnuts in the vicinity, and usually about 40 per cent of the seedlings from this tree are of the Paradox type. It is reasonable to suppose that the tree also crosses with the northern California black walnut, many large specimens of which stand close to this Arizona tree, but the pure seedlings of the northern California and *major* are so much alike that we have not been able to distinguish any hybrids between these two in the nursery.

Our experience, so far as it goes, seems to indicate that the English walnut and the Paradox do not cross very readily, even though the trees stand close together in the same orchard. Either this is the case or else the resulting seedlings are indistinguishable from those of the Paradox fertilized with its own pollen. Almost all Paradox trees are very light producers and their seedlings are of a fairly uniform type, with no individuals among them of exceptional vigor or differing noticeably in appearance from the majority. Only in the case of the Strong tree above mentioned have we found undoubted new crossing with the English walnut among the seedlings, and this tree, as we have said, resembles its black walnut parent much more than the English. Among its seedlings there is always a large percentage of undoubted first

crosses, showing as very vigorous, characteristic trees entirely different in appearance from those of the ordinary type. Such individuals have all the vigor of growth and other characteristics of first-generation Paradox trees.

With Royal hybrids the English seems much more free to cross and when English and Royal trees grow near together the resulting seedlings are very much mixed. We know of no large trees which can be positively ascribed to this cross, but have obtained numerous examples of them in the nursery among the seedlings of Royal trees which stood

FIG. 17.—Young Royal hybrid walnut tree, showing foliage.

close to English walnuts. Such individuals have all the vigor and desirable characteristics of the first cross.

Seedlings of Paradox Trees.—Paradox walnut trees of the first generation, that is, those of the first cross which originated directly from nuts cross-pollinated by other species, are almost without exception trees of unusual vigor and exceptional rapidity of growth. It would therefore seem that seedlings from such trees, grown from the nuts which they produce, would also be exceptionally vigorous trees. Such is not the case, however, especially as regards the use of such seedlings as rootstocks for the English walnut. These trees, in every instance which we have tried or known of, do not show exceptional vigor, and English wal-

nuts grafted upon them do not grow as well as a rule as those on straight black walnut roots. This subject will be discussed more fully in connection with root stocks.

ROYAL HYBRID WALNUTS.

The name Royal, as we have explained, was first given by Mr. Burbank to a supposed hybrid between the northern California black and *Juglans nigra,* the eastern black. From the first published description of this variety, however,* it would appear that the staminate parent, supposedly a northern California black walnut, was in reality itself a Royal hybrid, as the illustration of the nut of this tree shows a very rough, small nut which must certainly contain more or less *nigra* blood. Such trees are quite common about the streets of Santa Rosa. The Burbank Royal is presumably, therefore, at least three quarters *nigra* and one quarter northern California black.

Following Mr. Burbank's naming of this hybrid, the term Royal has come to be applied in California to all hybrids resulting from crossing between different black walnut species. There are many of these trees in the State, particularly about the older towns like Santa Rosa, San José, Vacaville, Winters, Chico, Red Bluff and other points in the Sacramento Valley, Stockton, Santa Barbara and other places. It is indeed difficult to find in the State a straight *Juglans nigra,* except those grown from nuts brought directly from the East. It is rather remarkable that the California species should hybridize so freely with *nigra,* inasmuch as their blooming periods are quite distinct, the true *nigra* coming out much later than any other black walnut. Such great variation exists indeed in these seedlings of California *nigra* trees that in some cases it seems difficult to account for all this variation on the basis of hybridization. For example, there are some *nigra* trees in the State planted from nuts which came from the East, which have all the charactertistics of the species. They are of slow growth, very late in coming out in the spring, early in shedding their foliage in the fall and bear the typical deep-grooved, sharp-ridged *nigra* nuts. When nuts from these trees are planted it often happens that almost none of the resulting seedlings are of the true *nigra* type, but they are hybrids, freaks, variations, mutants, or whatever we may call them. We were at one time inclined to the opinion that such variation was the effect of environment, causing a breaking up of the original species, but further study has brought us to believe that these are really hybrids. We are led to this opinion from the fact that the percentage of these unusual trees varies from year to year and that among the seedlings

*Supplement to New Creations in Fruits and Flowers, Burbank, 1898. See *Pacific Rural Press,* Feb. 5, 1898.

FIG. 18.—Burbank Royal hybrid walnut tree.

of these California *nigra* trees there are always some typical of the species, and some years a great many. Moreover, the progeny of certain trees are almost all straight *nigra* and the proportion of such normal seedlings is in inverse ratio to the opportunities for crossing with other walnut species.

Juglans nigra was planted quite commonly with eastern nuts in California in the very earliest years of the American occupation. Thus there are many large trees of the species now growing in the State. The trees are in almost every instance closely associated with specimens of both California species and also more or less with the English walnut. Many nuts from these original trees have been planted, and again those from the next generation, down to three or four or perhaps more generations. The result has been that about the older towns in the central and northern part of the State, trees may be found which present every degree of gradation between *nigra* and the California species and also many trees which have only slight resemblance to either, but might easily be classed as entirely new species if their origin was not known. It is hardly worth while to describe the individual trees of this sort, so numerous are they in the State. In some cases it is difficult or impossible to distinguish between hybrids and true *nigra,* as the nuts and foliage are very similar. Most of them, however, can be pretty certainly picked out on account of their unusual vigor of growth, the fact that they come out earlier and hold their foliage later than true *nigra,* a different aspect of the tree and foliage which cannot be definitely described, and the fact that the nuts are somewhat smoother and vary in other ways from those of true *nigra,* although various trees of the latter species have nuts of very different form and size.

The Royal hybrid is very different from the Paradox in regard to productiveness, being in almost every instance very precocious and an unusually heavy bearer of nuts. The most productive nut trees which we have ever seen are some of these Royal hybrid walnuts. In favorable seasons the ground beneath them will be covered several deep with nuts, while there are still so many on the tree that it is difficult to see where there could have been room for those which are upon the ground.

The cross between *nigra* and the northern California species is commonly illustrated in all the towns above mentioned. The Burbank Royal is an unusually fine tree, being of tall, erect growth, with a clean, uniform trunk, and of exceptionally vigorous and rapid development. It is a heavy bearer of very large nuts of a type more closely resembling those of *nigra* than those of the California species. The nuts, in fact, would pass for a fine large type of *nigra,* but are smoother than those of the usual type. They are deeply and much grooved, but not ridged to any extent.

There are other hybrid trees of spontaneous origin in the central and northern part of the State which are fully equal in every way to the Burbank type. These are too numerous for individual description. A particularly fine one is the Pleasants tree which stands close to the bridge on the county road near the old Pleasants ranch, between Vacaville and Winters. This is one of the most beautiful walnut trees in the State.

Juglans nigra crosses just as freely with the southern California black walnut or perhaps even to a greater extent than it does with the northern type, although this seems unusual since the blooming periods of the two species are several months apart. The most notable examples of southern California Royals are the El Molino or Oak Knoll trees, situated on the old Kewen or Mayberry ranch, now the property of Mr. H. E. Huntington and his son Howard Huntington, situated southeast of Pasadena in the Oak Knoll district. This place is well known on account of having upon it a picturesque old Spanish mill built by the Mission Fathers, from which the name El Molino is derived. In its original condition this place had two double rows of large black walnut trees, one extending on either side of a drive from the home site toward the south, to what is now Huntington Drive, and the other extending east and west to the west of the home site and the old mill, near the present residence of Mr. Howard Huntington. In going to Pasadena on the El Molino electric car line the first mentioned group of trees is situated a few rods to the east of the point where the El Molino line leaves Huntington Drive and turns in toward Oak Knoll and the Wentworth Hotel. The second group is found just to the east of the car line at the point where it starts up the hill below the Wentworth Hotel. Quite a number of other trees of apparently the same origin and generation as these may be found scattered here and there in dooryards and by roadsides through Pasadena, Alhambra, San Gabriel, El Monte, Covina and other neighboring localities. These trees are all of the same general type, being large, erect, with clean trunks and rather rough bark and having a general resemblance to *Juglans nigra.* It is evident, however, that none of them are entirely typical of that species. The nuts are all much smaller and smoother and quite different from the *nigra* type, all the trees come out much earlier in the spring and hold their foliage much later in the fall than typical *nigra* and they are all of much more rapid growth than *nigra.*

There stands on the Graves place, near the El Molino trees, a group of real *nigra,* planted from eastern nuts, and the difference is most pronounced between the trees in the two places. Mr. H. H. Mayberry, whose father was one of the early owners of the El Molino ranch, writes as follows concerning these trees: "There formerly stood in front of the

old mill building on the ranch a very large eastern black walnut tree that was cut down about 1883 or '84 and had a diameter of about four feet. This tree was, I believe, bearing when Colonel Kewen bought the property from a Mrs. Holt. The other black walnut trees were raised from seed from this original tree."

In the cañons back of this ranch, and at no great distance from the mill, there is still to be found a considerable number of native trees of the southern California type, so that presumably such trees were originally quite abundant here. It is, therefore, most reasonable to suppose that the various trees of this El Molino type are Royal hybrids, resulting from a cross between the old *nigra* tree by the mill and these wild southern California trees. It is remarkable, however, that all the seedlings grown from the nuts of this tree should have been hybrids, which appears to be the case. There are probably at least fifty of these seedlings represented by the present large trees on the ranch and a considerable number more scattered about the surrounding country, and not one of these trees can in any possibility be considered a true *nigra*. It may be that in planting these trees the largest specimens in the nursery were picked out and in this way nothing but hybrids were chosen. Such a case is indeed quite probable, as the straight *nigra* seedlings grow only a few inches the first year, while the hybrid trees among them may be several feet in height. Naturally these largest trees would be chosen for permanent planting.

Seedlings of Royal Hybrids.—The seedlings originating from first-generation Royal trees, of either the northern or southern California type, are in general much more vigorous and retain the qualities of their parents to a much greater extent than in the case with seedlings of Paradox trees. In the second generation, however, that is, trees twice removed from the original cross, the exceptional vigor is mostly lost and the seedlings become no better than or even inferior to those of the original species. In other words, the Royal hybrid seems on the average to retain its quality of exceptional vigor of growth one generation longer than does the Paradox. Various individual Royal trees, however, vary greatly in their ability to impart their characteristics to their progeny. Only a very few of them give seedlings which show uniformly a large percentage of trees as good as the parent. In the majority of cases the seedlings vary greatly and are not at all uniform. Almost always, however, the rule above stated is maintained that the seedlings of first-generation trees are more vigorous than those of the second generation, even though the parent trees may appear equally vigorous. This is an important fact in obtaining seed for nursery planting as a rootstock for the English walnut. In fact, it should be clearly understood that while Royal and Paradox hybrid walnut trees are quite common in the State,

these trees represent all sorts of relationships and degrees, a few being first crosses, but many more being of the second, third or even later generations. Of the trees tested by ourselves and by a few of the most progressive nurserymen who have taken the trouble to plant the nuts from various trees separately, only an extremely small proportion have shown themselves worthy of being used for producing rootstocks for the English walnut. To test such a tree thoroughly requires several years, inasmuch as the nuts must first be planted and the seedlings raised to grafting age, the trees then grafted and kept in the nursery for at least another year, after which they must be planted out in various types of soil and their growth observed for some time in comparison with that of trees on other roots. The majority of hybrid trees which produce seedlings of exceptional vigor among their progeny do this in an extremely irregular manner, the seedlings being of all sorts of sizes and characteristics. English walnuts grafted on such seedlings will vary correspondingly. As we have previously said, no Paradox trees have been found whose seedlings are desirable as rootstocks, and of all the Royal trees which have been tested there are less than half a dozen in the State at present whose seedlings are known to be of sufficient uniformity in good qualities to be desirable for propagation. Seedlings of most Royal hybrids are really inferior to those of the straight California black walnut of either species for nursery purposes on account of their lack of uniformity. At least one nurseryman in the State is taking the trouble to hybridize certain black walnut trees by hand in order to obtain a walnut cross which he considers especially desirable for the nursery.

One fact is to be remembered in connection with the progeny of any California walnut tree, namely, that in almost every instance walnut trees of some sort stand near to each other, and cross-pollination is therefore always possible and probably always goes on in every instance to a greater or less extent. The tree therefore which gives an unusually good lot of seedlings might not do the same at all if it stood elsewhere, removed from certain other trees which stand near it and which cross-pollinate its blossoms. It is therefore also true that it may or may not always be possible to perpetuate a desirable tree of this sort even by grafting, since when planted in some other place the combination of cross-pollination which resulted in the production of exceptionally good seedlings may be entirely lost.

FREAK WALNUT TREES.

Walnut trees are quite frequently met with in California which, while it is probable that they are mostly hybrids, present very peculiar characteristics and have little resemblance to any known species. It is possible that these may be partly the effect of environment as well as that of hybridization. About the city of Berkeley there are a number of

black walnut trees which do not coincide with any species known to the writer. There is a tree, for instance, on the University grounds just north of the creek in the rear of the old athletic field, which is of a peculiar type. This is a tall, clean-trunked, vigorous tree, having much of the appearance of a Royal hybrid and bearing a small smooth nut. The origin of this tree could not be ascertained. On the south side of Bancroft Way, just east of St. Mark's Episcopal Church, there is a row of black walnut trees which seem peculiar to themselves in regard to specific characteristics. There is another row of larger trees on the west side of College avenue, about midway between Oakland and Berkeley, in the Claremont district. All these street trees have a general resemblance to one another and look as though they might possibly be Royal hybrids. The writer has never been able to obtain any nuts from them. It is possible that they are all seedlings from some one tree.

On the El Molino ranch, above mentioned, there may be found in the cañon above the ranch in the Oak Knoll property several most peculiar trees. These vary in foliage and general appearance all the way from that of the English walnut to that of *nigra* and *californica* and bear all sorts of peculiar nuts. Some are quite large, some extremely small like those of *rupestris,* some rough, some smooth, some round, some elongated and some almost square. Mr. Fred Gray, now superintendent of the Leffingwell ranch near Whittier, who was formerly superintendent of the El Molino ranch, stated that he planted many of these cañon trees by taking nuts from the large Royal trees which we have described and throwing them about broadcast among the bushes and brush in the cañon. There are also growing in this cañon several trees of *Juglans californica.* There is a considerable number of old English walnut trees on the ranch in the immediate vicinity of the black walnuts and these peculiar trees therefore represent, presumably, a general mixture of the three species, *nigra, regia* and *californica.*

One tree in this cañon is especially peculiar. This has been called the pecan-walnut tree, under the assumption that it might possibly be a cross of the pecan with *nigra,* or the Royal hybrid. There are several pecan trees growing close to the black walnut trees on the ranch, so that opportunity exists for such a cross, if it were possible. The tree mentioned stands on the east side of the cañon near its opening, and in its general characteristics might easily pass for such a cross. The foliage resembles that of the pecan to a considerable extent; the bark is fibrous, striated and very close-fitting and smooth like that of the pecan; the wood has something of a pecan appearance, and the nut is exactly intermediate in character between those of the pecan and the eastern black walnut. The nuts are of an elongated oval form, pointed on both ends and deeply grooved. The seedlings of this tree,

however, give no reason to suppose that they contain any pecan blood. They resemble those of a good type of Royal hybrid walnut, and are very uniform in appearance. It is, therefore, safe to assume that this tree is a hybrid between *nigra* and *californica,* but one which has retained more of the characteristics of the latter species, as the foliage of this tree has considerable resemblance to that of the pecan. We have also found one or two other Royal hybrid trees in the State which bear nuts of an oval form, pointed at one or both ends very much like pecans.

Another peculiar freak is the so-called walnut-oak hybrid, which has been described and discussed by Babcock.* These peculiar trees originated in Orange County among a lot of seedlings of *Juglans californica.* Of the original trees there were about twenty among two thousand seedlings. The foliage of these trees is quite different from that of the walnut and resembles very closely that of a small-leaved oak. The fruit is peculiar, being similar externally in appearance to that of *Juglans californica,* but peculiar in the structure of the nut. The appearance and general characteristics of the tree are sufficiently characteristic to suggest very strongly that it might be a hybrid between the walnut and live oak tree, which grow in very close association in southern California. Efforts by Professor Babcock have thus far failed, however, to produce such a cross by artificial pollination, and he has come to doubt whether this is the true explanation of the origin of this peculiar form. Since the first lot of trees of this kind was noticed a few other similar individuals have appeared among seedlings of *Juglans californica.* It should have been said that nuts of some of these trees are fertile and produce seedlings, some of which have foliage like the parent, while others appear to have reverted to the walnut type of leaf.

The native American species of walnut when grown in California certainly present a unique example of freedom in hybridization and variation. It has not been possible in the present work to go into this matter from a technical standpoint, and we have perhaps already given more space to the subject than it deserves in a publication upon walnut culture. We desire, however, to record the status of the matter and call the attention of plant breeders and those interested in similar work to a most promising field of investigation.

*E. B. Babcock, The Plant World, Vol. 13, No. 2, Teratology in *Juglans Californica*—Watson. Silva of California—Jepson, p. 50, The Walnut Oak Hybrids.

FOSSIL WALNUT SPECIES.

Many species of walnut seem to have existed in this and other countries in prehistoric times. We quote as follows from Sargent: "The type is an ancient one in Europe, from which later it entirely disappeared, existing in the cretaceous flora and abounding with many species during the tertiary epoch; in North America traces of *Juglans* appear in the eocene rocks of the northern Rocky Mountain region and of the northwest coast from Vancouver Island to Alaska, regions where no representative of the walnut family now exists, and in the auriferous gravel deposit of the California Sierra Nevada."*

WALNUT CULTURE IN CALIFORNIA.

HISTORY.

The first English walnuts in California were probably brought by the Mission Fathers, although this crop does not seem to have been especially prominent in the earlier Mission plantings; it was only after the coming of the first Americans and the discovery of gold that English walnuts began to be extensively planted in the State.† The first trees were of the so-called hard-shell type, bearing rather small, roundish nuts, with a very hard shell. There are still a few trees in the State of these early plantings, but most of them have been removed. Such trees were planted in orchard form to a limited extent by some of the pioneers, but in its present form the walnut industry is of comparatively recent origin. Laying aside the sometimes discussed question as to whose was the first walnut orchard in California, or who introduced or developed certain types of nuts, it can fairly be said that the present California walnut industry owes its origin preëminently and fundamentally to the efforts of two men: Joseph Sexton of Santa Barbara and the late Felix Gillet of Nevada City. The former was the originator and first propagator of the Santa Barbara Soft Shell type of nut, of which practically all the producing groves of southern California are at present composed, and the latter was the first introducer and life-long promoter of the various French varieties which form the basis of the northern California walnut industry as it exists to-day. A great many others have done much to promote the walnut industry both in the south and the north, but their names are too many and their services too varied to be mentioned and properly estimated here. It can and should fairly be said, however, that practically all the desirable types of walnut now in the

*Silva of North America.

†The historical side of the subject is well treated by Lelond, in Rep. Cal. State Board of Hort. for 1895-96.

State trace back in their first introduction either to Mr. Sexton or to Mr. Gillet, and that the few isolated exceptions to this rule occurred largely by chance, and were not systematically carried on and continued by any one person.

FIG. 19.—Joseph Sexton, originator of the Santa Barbara Soft Shell walnut.

The old fashioned hard-shell walnuts were planted quite commonly in California after the commencement of the American era, although not extensively in orchard form at first. The Kellogg orchard near Napa is said to have been planted in 1846 and the Heath orchard at Carpinteria

was also one of the earliest plantings. Other scattering plantings were made, composed mostly of dooryard rather than orchard trees, but it was not until a number of years later that the walnut began to be looked upon as a commercial crop worthy of being planted extensively in orchard form. The latter stage of the industry came about largely as a result of the development of the so-called Santa Barbara Soft Shell nut by Mr. Sexton. The history of this variety has been given to the writer by Mr. Sexton as follows: In the spring of 1867 he bought in San Francisco a sack of walnuts which came probably from Chile. These nuts were planted that spring and from them about 1,000 trees were raised, of which Mr. Sexton planted about 250 himself in orchard form on his place at Goleta. Sixty of these proved to be of the so-called paper-shell type, the rest being ordinary hard-shells. Only one of these 250 trees is still in existence, this being a hard-shell. Nuts from these trees, mostly from the paper-shells, were planted in the nursery by Mr. Sexton, and from these came the first of the so-called Santa Barbara Soft Shell trees. Of the first of these second-generation seedlings sent out by Mr. Sexton several groves are still in existence, mostly in Santa Barbara and Ventura counties. The trees vary considerably in type, some being typical hard-shells, some paper-shells and others of an intermediate type, which represents what may be called the typical soft-shell. The latter type was considered the most desirable, the trees being of more vigorous growth and making greater size than either the hard-shell or paper-shell, while the nuts were larger than those of either of the other types and of a more desirable thickness of shell. The oldest of these original Santa Barbara Soft Shells are now between 30 and 40 years of age. Nuts were again planted from the best of these trees and soon the present walnut industry of southern California began its development, based almost entirely upon the type of nut originated by Joseph Sexton. Extensive planting began in Santa Barbara, Ventura, Los Angeles and Orange counties, all the groves with practically no exception being composed of seedling trees of this new type. The industry developed very rapidly and under an enormous demand for trees, nuts of all sorts were planted with no regard to selection in many cases. The result has been that at the present time the Santa Barbara Soft Shell seedling groves are composed of a most heterogeneous collection of trees in regard to type of nut and bearing qualities. Comparatively few trees of the many, many thousands now in existence are equal to the best of those in the oldest groves, and there is a still smaller percentage of trees superior to these oldest ones. The oldest and best soft-shell trees produce a fairly uniform type of nut and are all heavy bearers, turning off, in spite of blight and other vicissitudes, more than 300 pounds of nuts per year. They are fine, large, thrifty trees, still in healthy, vigorous condition wherever planted in good soil, and it may truly be said that were the

present groves composed of trees of as good average quality as the best of these oldest trees, the walnut industry would be at present in far better condition than it is.

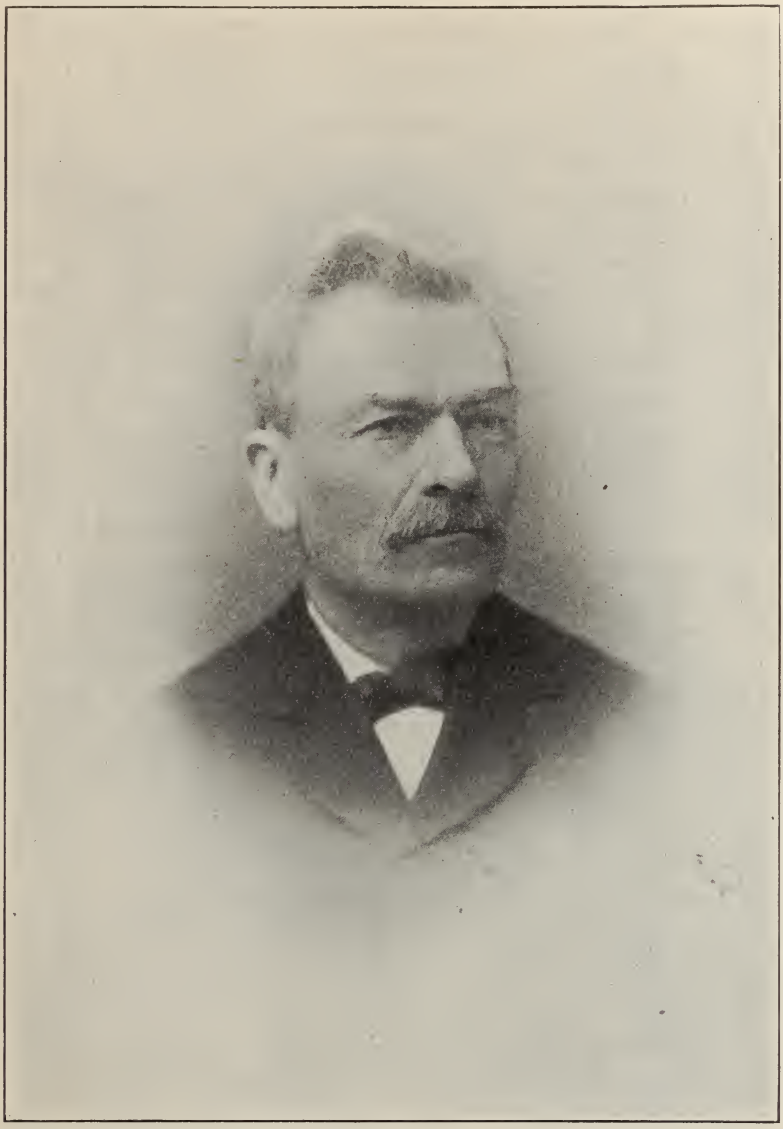


FIG. 20.—Felix Gillet, introducer of the best French walnuts into California and originator of most of the French seedling varieties.

As plantings and the number of bearing trees of the Santa Barbara Soft Shell type multiplied, particularly thoughtful growers here and there began to notice the variation in the trees and to consider the possibility of propagating from the best of them, both by seed and by grafting.

Many orchards were planted with seedling trees derived from especially selected nuts, but the greatest step in advance was taken when trees of special excellence began to be picked out here and there and propagated by grafting or budding in the same manner that other fruit tree varieties are propagated. Thus originated, for instance, the Placentia Perfection, Ford's Improved, Disher's Prolific, El Monte, and various other varieties of which the original trees were Santa Barbara Soft Shell seedlings. Much difference of opinion existed at first as to the merits and qualities of the grafted tree in comparison to the seedling, and there was in the beginning a strong prejudice against the former and an idea of inherent superiority of the seedling tree in thrift, vigor and productiveness. As time went on, however, abundant proof was afforded, through the rapidly increased plantings of grafted trees, that this difference was entirely imaginary and that no radical difference existed between the walnut and other fruit trees, whereby the superior qualities of particularly desirable individuals could not be reproduced and multiplied indefinitely. Thus at the present time the planting of seedling trees has practically ceased and no well-informed grower would consider the planting of a seedling grove.

In the northern part of the State the walnut industry has had quite a different development. Trees of the old hard-shell type were planted in this portion of the State as early as in the south, but the extensive development of the industry in the latter portion of the State based on the Santa Barbara Soft Shell type of nut did not extend north of Santa Barbara County. The pioneer and chief promoter of walnut culture in northern California was Felix Gillet of Nevada City. Born in France in 1835, Mr. Gillet came to this country in 1852, arrived in California in 1858 and in 1859 in Nevada City, which place thereafter remained his home. Mr. Gillet had a natural interest in horticulture, and in 1871 began the development of his Barren Hill Nursery. He was particularly interested in nut culture and at a very early date began introducing from France the best of the nuts grown in that country, particularly the walnut. From 1871 on he imported many shipments of scions and nursery trees, and was the first introducer into California of practically all the French walnut varieties which we now have. He likewise propagated trees of these varieties in his own nursery and also raised many seedlings from French varieties with the idea of developing new varieties of special adaptation to California. As a result of Mr. Gillet's efforts the Franquette, our leading walnut in the northern part of the State, was established in California, while from seedlings of his raising originated the Concord, San José, and possibly the Chase varieties.

Following Mr. Gillet, further introductions from France were made

by various parties of the varieties to which he had called attention, and the planting of the best of these, particularly the Franquette, was carried on by various people. Without question, the chief credit for the present popularity of the Franquette variety is due to the late Mrs. Emily Vrooman, who planted an extensive grove of this variety near Santa Rosa at a time when walnut growing on a commercial scale in northern California was still considered doubtful or impossible. As a result of the success of Mrs. Vrooman's grove, others came to appreciate the possibilities of walnut culture in the northern part of the State and the valuable qualities of the Franquette variety. In later years there has been a growing interest in walnut culture in the central and northern part of the State, which has been shared in and assisted by numerous individuals who cannot be mentioned individually here.

LOCATION FOR WALNUTS.

CLIMATE.

The limitations of commercial walnut growing are rather closely drawn by climatic conditions.

Frost.—In regard to temperature, the tree is able to withstand a considerable degree of cold so long as it is not subject to severe frost and freezing outside the period of dormancy, and also provided the trees do not suffer for moisture during the dormant period. English walnut trees are not uncommon in the Atlantic States as far north as New York, and there are trees even in Northwestern New York which bear well every year. The most evident effects of freezing upon the walnut are seen in cases where heavy frosts come on suddenly in the fall while the trees are still green and not yet in a dormant condition, or when the same thing occurs in the spring after the trees have commenced growth. In the latter case, even in southern California, walnut trees are sometimes badly frozen. In general, it may be said that so far as winter temperatures are concerned, the tree is almost as hardy as the peach or apricot and will flourish almost anywhere in California where these trees do well. In regard to late spring frosts, it is fortunately the case that different walnut trees and varieties vary widely in regard to their time of coming out in the spring, ranging in this respect over a period of several months. It is thus possible in a locality subject to late spring frosts to select a late variety of walnut and thus escape the danger period. It may, therefore, be said in respect to low temperatures that walnuts can be grown in practically all the cultivated portions of California, so far as this one feature is concerned, by choosing varieties of the proper foliation period in the spring. In the central and northern parts of the State there has been in general too

much fear of spring frosts in relation to walnuts. About almost any of the towns in this portion of the State there may be found early trees, which to all appearances produce as regularly and abundantly as those in the south. While walnuts are sometimes damaged by frost even in the best of the southern California districts, the tree is not unusually sensitive in this respect and even the earliest of our walnuts come out later than many of our ordinary fruit trees. We very much doubt whether the walnut in many northern California districts would be injured by frost any more than the almond, apricot, peach or grape, and the prospective grower need not absolutely discard all early varieties for this one reason alone. It may further be said that during the spring of 1911 when there was much late frost in the State, some of the latest varieties of walnut were badly injured, when earlier varieties in the same locality had reached sufficient development so that they withstood frost with no injury whatever.

Trees which suffer for moisture during late fall and winter are likely to be severely killed back at temperatures which otherwise would not affect them. See Die Back, page 372.

Heat.—The walnut tree is one which does not take kindly to extreme summer heat, and its commercial culture is limited to a considerable extent by this factor. In the extremely hot desert valleys of the State the tree is not at all well adapted, becoming injured and repeatedly killed back by drying and burning of the leaves and tender shoots. The idea which once prevailed, however, that walnut culture is possible only in the immediate vicinity of the coast has become considerably modified in recent years. Sufficient plantings have been made to indicate that the tree flourishes practically all over the State, except in the very hottest and driest portions, and it has been demonstrated that nuts can be produced over a similar territory. A serious drawback, however, is the burning or discoloration of the nuts by the sun even in localities where the tree flourishes well. Here again the matter of choice of varieties becomes important since there is much variation in its susceptibility to sunburn. The most serious form of sunburn takes the form of an actual shriveling and blackening on one side of the green hulls of the immature nuts. This is worst on the nuts which are most exposed to the sun, also on trees which are unthrifty or not in a good vigorous condition. Walnut trees or varieties best adapted to the hottest localities are, therefore, those which have the most abundant foliage, in which the nuts are borne well down among and under the leaves, and which are naturally of thrifty, vigorous growth. Burning by the sun is also less severe upon trees standing in good soil with plenty of moisture than upon those in light dry soil. A less prominent effect of sunburn consists in a burning or discoloration of the thin pel-

licle which envelopes the kernel of the nut. In very hot places such discoloration occurs even without visible burning of the outside of the husk. This effect, however, like that of frost, is one which we believe to have been largely overestimated. There is much difference in different trees or varieties as to the color of the pellicle, but in good, white-meated varieties we have seen nuts of perfect quality in this respect produced in very hot localities in the interior of the State. Where the heat is not so severe as to scorch the foliage, stunt the growth of the tree, or visibly burn the nuts, little attention need be paid to this discoloration of the pellicle so long as proper varieties are planted. The chief consideration in the warmer localities should be to choose varieties of vigorous growth, with abundant foilage, well shaded nuts and thick husks.

Hot dry weather at the time of blooming in the spring is sometimes as disastrous or even more so than frost. There is little danger of this in the northern part of the State, but in the south the setting of nuts is sometimes seriously damaged by conditions of this sort, and indeed this danger is sufficiently great to make the planting of any late variety of doubtful advisability in the south.

Specifically, we may say in regard to the climatic limitations of walnut culture in California that wherever suitable soil and water supply can be obtained and by the proper choice of varieties, the crop can be successfully produced in all the counties of southern California save in the desert portion, in almost all the coast counties of the State, except in localities very much exposed to cold wind and fog a large portion of the time, in all the valleys about San Francisco Bay and in most of the country within 200 miles of San Francisco or even further. In the interior valleys no definite line can be drawn where commercial walnut possibilities cease, as in these warmer regions much depends upon soil and moisture supply. In the mountain districts walnuts can be grown almost anywhere except at the higher altitudes where spring and summer frosts are of regular occurrence.

SOIL.

A fairly heavy, deep soil with an abundance of moisture, though at the same time thoroughly well drained, presents by far the best condition for successful walnut culture. Very little success can be expected on light sandy soil subject to a fluctuating moisture supply and walnut culture should not be attempted under such conditions. Trees on such soil are less thrifty, less productive, and much more subject to all the troubles which affect the walnut in this State. Walnut trees on light soil may flourish for a time, especially if plentifully supplied with water and in the beginning of the industry in this State it was thought that such were the best conditions for walnuts. Trees grown in this

way, however, have proven to be short lived and more subject to disease, and nothing has been more positively demonstrated by experience than the desirability of heavy soil for the walnut. The quality of the subsoil is of particular importance since the roots of the walnut go down fairly deep. A strong or heavy (though not wet or impervious) subsoil is absolutely essential.

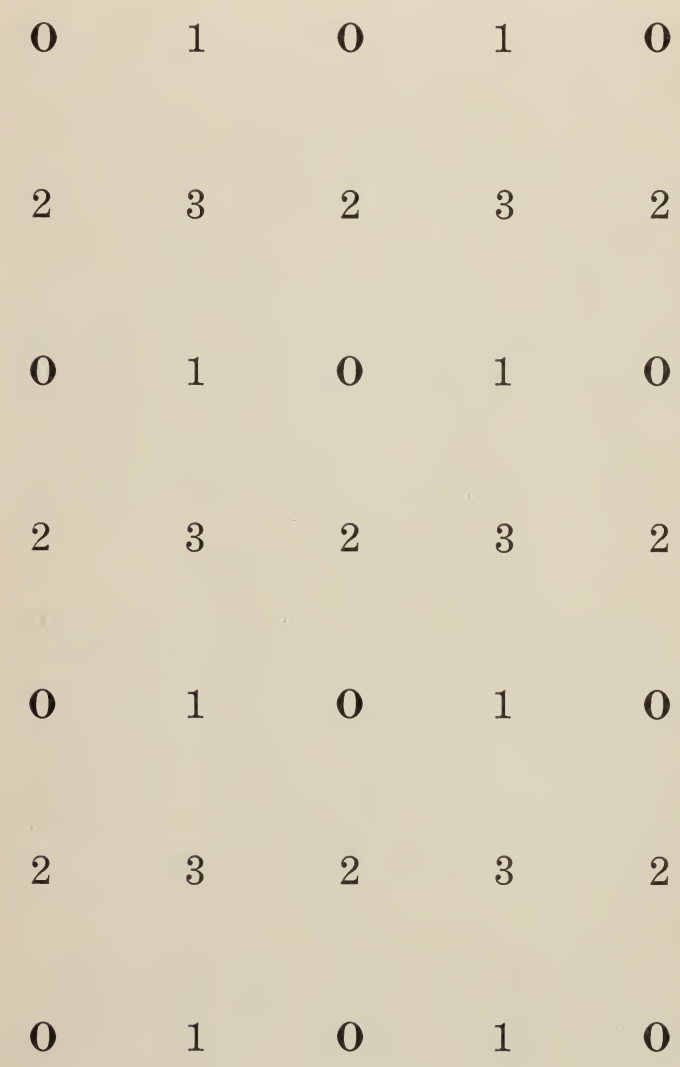
A uniform and abundant supply of soil moisture is necessary, although the tree is considerably resistant to drouth, especially when grown on proper roots. Walnuts are frequently grown in California without irrigation even in the southern part of the State, but unless planted upon soil of exceptionally good water-retaining capacity more or less irrigation is almost always beneficial and profitable. In many cases where the trees survive and do fairly well without water they would grow much more rapidly, come into bearing sooner and bear much larger crops if supplied with water. Too great an amount of moisture in the soil with water constantly standing near the surface is very unfavorable to walnut culture and the trees will not long withstand conditions of this sort. Some latitude can be obtained in this respect by the use of a root best adapted to excessive moisture, but it is hazardous to attempt walnut culture on land where the water level stands within less than eight feet of the surface or where it is likely to rise after the trees are planted.

DISTANCE OF PLANTING.

In practically all the older walnut groves in the State the trees were planted too near together. The walnut tree is one which continues growth for many years, making a large, spreading top, so that the trees very soon come together unless planted a long distance apart. Furthermore, the production of nuts seems to be particularly favored by exposure to the light and open air on all sides of the tree. The mistake of planting the trees too close together should therefore be carefully guarded against. With vigorous growing varieties on good soil 60 feet apart is none too much, and less than 50 feet should not be considered in any case. Sixty by sixty feet gives about 12 trees per acre, 50 by 50, 17 trees per acre and 40 by 40, 27 trees per acre, when planted in squares. By alternating the rows these numbers are slightly increased.

Interplanting.—With trees planted at these wide intervals and also somewhat slow in coming into bearing as compared with many fruit trees, it becomes quite desirable when planting walnuts to interplant with some other tree or crop in order to get something off the land while the walnuts are coming into bearing. Fortunately, this is not especially objectionable, as the walnut is a deep rooting tree, and, if properly treated, shows no injurious effects from judicious interplanting. In some cases interplanting or double planting with walnuts is practiced,

either with the same variety as that of the permanent planting, or with another more precocious, though ultimately less desirable, variety. Such interplanting with walnuts may be done either in one or both directions, so that there may be two, three, or four times as many trees per



Diagram, showing method of quadruple-planting of walnuts in squares. 0=permanent trees, 60 feet apart. 1=trees for first cutting out. 2=second cutting. 3=third cutting.

acre as will remain permanently, according to the extent to which the interplanting is done. The only objection to such interplanting as this lies in the reluctance of the average man to cut out the temporary trees

when the proper time arrives. So weak has human nature proven itself in every instance of such interplanting with which we are familiar that we hesitate in recommending this method. The trees grow rapidly

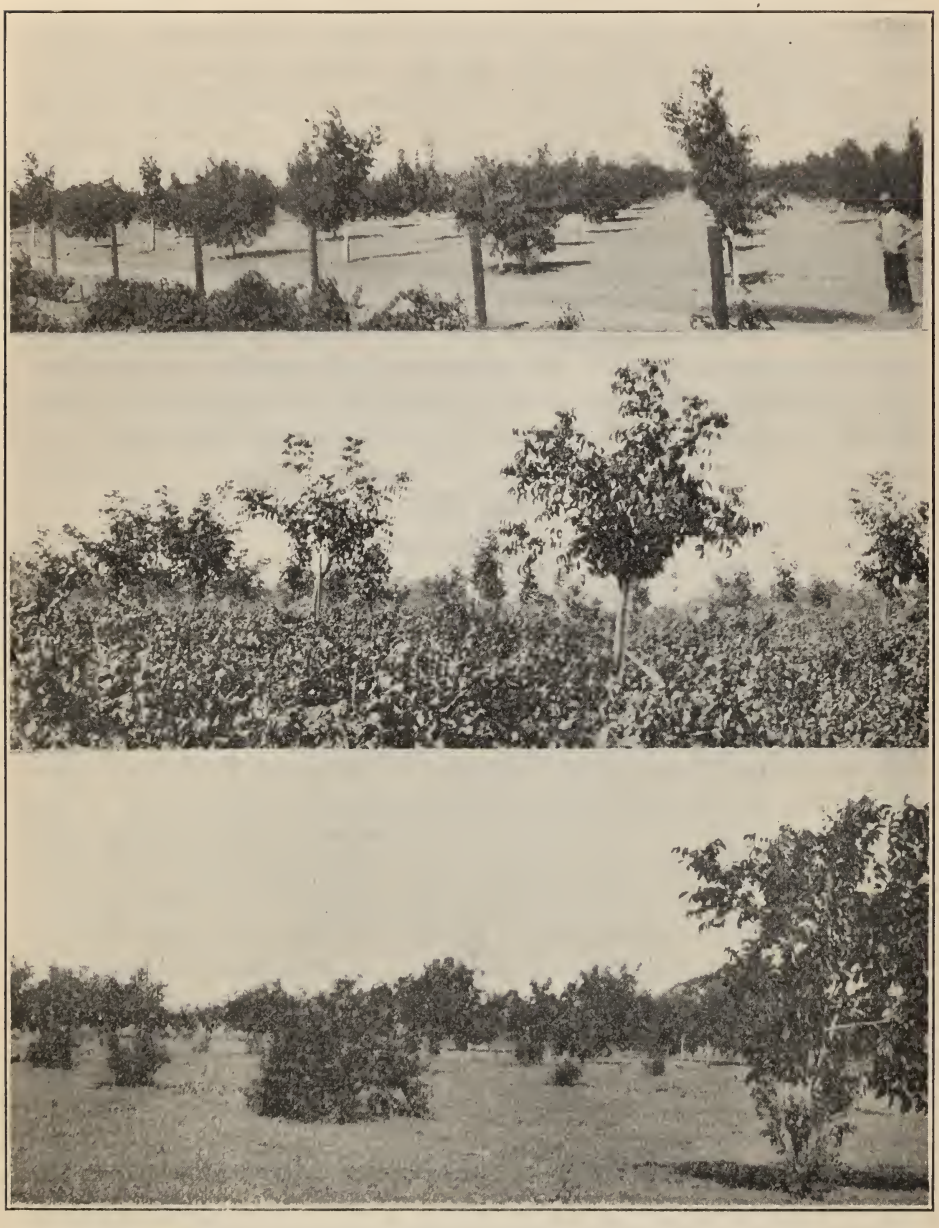


FIG. 21.—Top—Interplanting with peaches. Center—Grapes. Bottom—Grove started by planting nuts in place.

and for proper results must be ruthlessly slaughtered just as they are coming into their prime. Unless one is fully prepared to carry out such

a slaughter, however, just as soon as the tops begin to reach out and touch each other, he should not consider interplanting with walnuts. If double planting is practiced in both directions, using four times the number of permanent trees per acre, the cutting may be extended over at least three years, taking out one fourth of the trees each year. Interplanting is frequently done with peaches, apricots, grapes, berries and other quick-maturing fruits, also with all sorts of vegetables and annual crops. There is no objection to any of these, so long as the walnut trees are protected from injury and do not suffer for moisture. The latter is one of the greatest dangers and should be carefully guarded against. Interplanting with alfalfa is a common practice and a very desirable one if the alfalfa does not rob the walnut trees of moisture. The latter, however, is frequently the case. In order to guard against this, the walnuts should not depend for irrigation upon the water which they get along with the irrigation of the alfalfa. A cultivated strip should be maintained on each side of the walnut rows and water should be run in separate furrows for the irrigation of the trees.

CULTURE.

SOIL HANDLING.

The various operations of stirring the soil, such as plowing and cultivating, do not appear to be of as much importance in walnut culture as in the case of some other trees. In relation to the conservation of soil moisture cultivation has its importance, particularly where the water supply is somewhat limited, but given plenty of moisture and suitable soil the walnut tree is one which seems to flourish and produce satisfactory crops whether the ground be thoroughly cultivated or not. It is, indeed, a matter of common observation to see large, thrifty walnut trees producing the best of crops while standing in the hard-packed soil of the dooryard or roadside with no cultivation whatever. In fact, trees in such situations seem sometimes to flourish actually better than those in neighboring orchards where some degree of cultivation is practiced. Many growers call attention to trees standing in the dooryard or about the buildings where they receive no cultivation and little or no irrigation, which are noticeably in better condition and more productive than trees near by planted in orchard form. The superiority of such trees is not due, however, to their lack of irrigation and cultivation, but rests largely upon the fact that being planted away from other trees they have better exposure to the light and air than trees in the orchard, which appears to be a very essential factor with the walnut. Again, it is true that walnut trees, if they stand in fairly good soil, actually do better without any cultivation than they do if the ground is plowed or cultivated occasionally in a superficial, unsystematic manner. The tree

apparently retains much of the nature of a forest tree in this respect and does better when left to itself with the soil undisturbed than when the soil is cultivated in the above-described irregular manner. This by no means goes to prove, however, that good cultivation is injurious or unnecessary in walnut culture, for experience has shown this to be far from the case. Especially in regions where the rainfall is limited and the dry season long and hot, regular, thorough cultivation is as beneficial and profitable in the walnut orchard as with citrus or other trees. In regions with more abundant rainfall and less severe dry seasons cultivation is not so essential; the chief consideration in all cases is that of the conservation of soil moisture. The latter must be maintained, but whether by irrigation or cultivation matters little. If the soil is sufficiently moist cultivation is not as essential with the walnut as with many other fruit trees.

In practice it is customary to plow the grove once a year during the spring, followed by harrowing and cultivation to put the soil into good mechanical condition. After this, the ground is usually cultivated occasionally during the summer, at least after each irrigation if this be practiced, in order to keep it from baking, keep down the weeds and hold the moisture. A number of growers in southern California have tried in recent years the experiment of carrying on their walnut groves with no plowing or cultivation whatever, but with abundant irrigation. In some cases permanent irrigation furrows have been made between the trees, while in others the water is simply turned into the orchard and allowed to flood the whole ground as thoroughly as possible. The weeds and grass have been allowed to grow up or pastured off with horses and cattle. Under such treatment an actual improvement has been manifest in the condition of some walnut groves. Whether such improvement, however, is due to the lack of cultivation we are inclined to doubt, but would rather attribute it to the increased water supply which the trees have received. Such experiments have strengthened the opinion, however, that cultivation is not particularly essential with the walnut so long as it receives plenty of moisture. In cases where walnuts are grown without irrigation there can be no question that thorough, systematic cultivation during the summer season will assist in holding the moisture of the soil. That many trees grow and flourish without such cultivation and without irrigation is again no indication of beneficial effects of non-irrigation, but simply shows that in these particular localities sufficient soil moisture is present without any special efforts toward its conservation.

IRRIGATION.

The walnut tree, while not dependent upon constant irrigation like the orange and many other more shallow-rooted trees, is at the same time a large consumer of water and needs plenty of moisture for successful

development. The majority of the trees in the northern part of the State are grown without irrigation, and even in the southern part many groves receive little or no water in addition to the natural rainfall. In seasons of abundant precipitation trees under such conditions get along very well, and it may be said that the walnut is as well adapted as almost any of our ordinary fruit trees to grow without irrigation. There are localities, especially in the northern part of the State, where the crop can be produced successfully and regularly without irrigation. Furthermore, there is considerable variation in the moisture-gathering ability of the various kinds of root upon which the tree may be grown so that by proper choice in this respect much may be done to make walnut growing possible on non-irrigated lands. In general, however, it is true of walnut growing, as with all other fruit growing in California, that no one factor is as desirable or useful as the possibility of an abundant and regular water supply. Even though the trees may be able to live without irrigation and may grow quite well and produce good crops during most seasons, it is still true that even as a matter of insurance against dry years a possible water supply is extremely valuable. Furthermore, there is no spot in the State so favored with natural soil moisture but that with irrigation during the first few years the trees would grow much faster, come into bearing earlier, and produce more satisfactory returns to the owner.

By this, however, we do not intend to discourage the planting of walnuts on non-irrigated lands. The tree is, as we have said, as well adapted to such conditions as any other fruit tree, and, indeed, may be grown more successfully without irrigation than most other fruits if grown upon a proper root.

As to the particular methods of irrigation practiced with the walnut, it may be said that the tree is most likely to suffer from lack of moisture during the fall and winter after the crop of one season is off and before that of the next year has started to develop. Quite frequently it is the case that the fall rains are late in commencing and the walnut tree is especially likely to suffer from such a condition. Although it may not be in active growth and practically dormant, a lack of moisture at this times dries out the branches, twigs and buds, lowers the vitality of the tree, impairs its vigor for the following season, makes it more susceptible to injury by cold, and is in many other ways injurious and disastrous. For this reason it is coming to be more and more the practice among the best walnut growers to irrigate heavily during the fall and winter, supplementary to the winter rains and creating a storehouse of moisture in the soil for the summer. If the subsoil is thoroughly soaked down and not allowed to become dried out during the fall and winter, the tree, on fairly heavy soil at least, is much less dependent upon summer irrigation than is the case with citrus and many other trees.

During the summer it is ordinarily desirable to irrigate at least once or twice, especially toward the time of maturity of the crop, in order that the nuts may have plenty of moisture for their proper development. Walnut irrigation therefore resolves itself very largely into, *first,* guarding against drying out of the soil during the fall with irrigation at this time if necessary to accomplish such a result; *second,* copious irrigation during the latter part of the winter, unless the rains have been sufficient to thoroughly saturate the subsoil down to the depth of the lowest roots; *third,* at least one irrigation during the summer, usually in August, when the nuts are approaching maturity. When interplanted with other crops greater care must be given to irrigation than otherwise, since these other plantings will draw a large amount of the moisture which would otherwise be available for the walnut trees.

FERTILIZATION.

Very little of a specific nature can be said upon this subject since no definite data are available in connection with the fertilization of walnut groves. Fertilization has been practiced to some extent by walnut growers and an extensive experiment was arranged and carried on for several years at one time by ourselves. In no case, however, have sufficiently definite results been obtained to justify any specific recommendations in regard to the requirements of the walnut tree in this respect.

The experiment mentioned may be described at this point.

Fertilizer Experiment.—A coöperative arrangement was made with the Cudahy Ranch, situated just south of the city of Huntington Park, near Los Angeles, to carry on a fertilizer experiment upon walnut trees on a considerable scale. A block of Santa Barbara Soft Shell seedling trees was chosen for this purpose, consisting of 56 rows of 21 trees each, a total of slightly over 1,000 trees, comprising between 50 and 60 acres of grove. Each of the various fertilizers or combinations used was applied to two rows of trees, so that there were 42 trees in each plot. At the time of commencing the experiment in 1907 part of the grove was five and part six years old, the different applications being arranged in such a way as to bring about comparative tests on trees of the same age. The soil of the experimental orchard consisted of a sandy loam, being decidedly more sandy on the west end and gradually becoming heavier toward the east. The rows ran north and south so that the westernmost plots were on much lighter, sandier soil and the trees were smaller than those farther east. Except for these smaller trees at one end the grove was as uniform as any seedling grove of this size which could be obtained. This variation was provided for by duplication of plots. The fertilizers were applied for two successive

years, 1907 and 1908, all expenses being met by the Cudahy Ranch. Applications were made as follows, each plot consisting, as said before, of two rows or 42 trees:

Plots.		1907. Pounds per tree.	1908. Pounds per tree.
1 and 2	No fertilizer		
3	Dried blood	10	30
4	Sulphate of potash	10	10
5	Steamed ground bone	15	20
	Bone superphosphate	15	20
6	Stable manure	Heavy	Heavy
7	Sulphate of potash	0	5
	Stable manure	Heavy	Heavy
8	Dried blood	0	20
9	Bradley's fruit and vine	40	50
10	A. C. W. walnut fertilizer	40	50
11	No fertilizer		
12	Nitrate of soda	24	25
13	Sulphate of ammonia	20	20
14	Tankage	30	35
15	Muriate of potash	10	10
16	Sulphate of potash	10	10
17	Stable manure	Very heavy	Very heavy
18	No fertilizer		
19	High grade rock phosphate	35	40
20	Steamed ground bone	15	20
	Superphosphate	15	20
21	Nitrate of soda	15	25
	Superphosphate	20	40
	Sulphate of potash	4	10
22	Nitrate of soda	15	25
	Sulphate of potash	4	10
23	Nitrate of soda	15	25
	Superphosphate	20	40
24	Sulphate of potash	4	10
	Superphosphate	20	40
25	Sugar factory lime (2 tons per acre each year)		
26	No fertilizer		

It will be noted that many of these applications were comparatively large, costing in the vicinity of $1.00 per tree per year. No record of the crop was kept until 1909, when a careful weighing was made of the crop of each individual tree in the whole experiment. The detailed results will not be given in this bulletin for the reason that they were not sufficiently conclusive to warrant their publication. So far as the effects of the various fertilizers were concerned no conclusions whatever could be drawn. This is due partly to the extreme variation in yield of the individual trees, which completely obscures any effect of fertilization, and also to the fact that even where fairly good comparisons could be made the fertilizer applied showed a surprising lack of decided effect. The crop on the various trees in the experiment varied from a minimum of less than one pound up to a maximum of 117.5 pounds. With such a range it is almost impossible to draw any conclusions from the effects of the fertilizer, even when the crops of the 42 trees in each plot were averagd.

The most valuable results obtained from the experiment were, first, the demonstration of the variation in production in seedling trees, and second, the relation of soil texture to walnut production. On the first point we may repeat what has been said, that the various trees varied from one to 117½ pounds in their total production.

On a block of 400 trees on fairly uniform soil 148 trees, or 37 per cent, produced less than 10 pounds each; 118 trees, or 29½ per cent, produced from 10 to 25 pounds each; 82 trees, or 20½ per cent, produced from 25 to 50 pounds each; 26 trees, or 9 per cent, produced 50 to 60 pounds each; 10 trees, or 2½ per cent, produced 60 to 75 pounds each; 5 trees, or 1¼ per cent, produced 75 to 100 pounds each; and 1 tree, or ¼ per cent, produced over 100 pounds.

To show further the variation in production in seedling trees under almost exactly the same conditions, the crop from adjacent trees in some of the individual rows may be stated. In row 20, for instance, the production in pounds per trees was as follows: 1.4, 16, 45.6, 10.5, 21.5, 97.4, 20.5, 8, 26.3, 0, 16.4, 1, 18.6, 13.5, 10.6, 21.5, 2, 31, .7, 14.8. Another row, 3, 72.5, 32, 27.5, 58.9, 9.8, 69.5, 22.2, 30.5, 8, 44.5, 38.5, 20.1, 19.1, 13.5, 34.8, 5.5. In the case of the 117.5 pound tree, the 6 trees surrounding it produced as follows: 6, 24, 14, 28.5, 27, 23. These were all Santa Barbara Soft Shell seedling trees in their eighth year in the orchard at the time these weighings were made. The same variation runs through all the figures and it is impossible to deduce any reliable conclusions as to the effect of the fertilizers. A study of the figures obtained, taken together with an examination of the trees as to general appearance, gives one a fairly strong impression that the greatest benefits were derived from the application of stable manure and that of nitrogenous materials. Such results would certainly be expected, especially in this rather sandy land, yet even so, it is surprising to note the lack of pronounced results from the application of the large quantities of these materials which were used. For instance, in the plot of 42 trees which received during the two years 40 pounds of nitrate of soda, 60 pounds of superphosphate and 14 pounds of sulphate of potash per tree, the average product of the 42 trees was about 28 pounds of nuts. In the plot which received the same minus the nitrate of soda, the average product was exactly the same; in that which received the same minus the potash the average was 33 pounds, while in that which received the same minus the superphosphate it was also 33 pounds. These plots were all near together on the same type of soil and with trees as uniform in appearance as can be found in any seedling walnut grove. The stable manure plot averaged about 31 pounds, while the adjacent check plot

which received no fertilizer averaged only 20 pounds, which difference is the only striking one obtained in the whole experiment.

The effect of differences in soil is very marked in comparing the crops of the west and east ends of the orchard, on the light and heavier soils respectively. On the ten west rows of the eight-year-old trees, the crop averaged 16.3 pounds per tree, while on the ten east rows of the same block on heavier soil it averaged 30 pounds per tree. These were all trees of approximately uniform appearance and not especially stunted where the smaller yield was obtained. The westernmost row averaged 7.56 pounds per tree, while the easternmost averaged 32.56. Between the two the average production per row graded off fairly regularly regardless of the fertilizer used.

The results of this experiment are typical of all experience in fertilizing walnuts. Many attempts have been made to determine the most effective practice in this respect, but all of these have shown no positive effect on account of variation in the trees and an apparent lack of response to fertilizers. In regard to walnut fertilization it is, therefore, impossible to offer definite advice based on actual experiments, but the most that can be done is to suggest such practice as may reasonably be expected to give good results with any crop on California soils. We know in general that nitrogen and phosphoric acid are our most needed elements and that the application of these substances, especially on older plantings, is almost certain to result in improved growth and vigor in almost any plant. We also know of the walnut that individual trees produce as a general rule in proportion to their size, and that the larger they become the greater crops they will bear. It is, therefore, our conclusion that in fertilizing walnuts nitrogen and phosphoric acid should be the elements most largely supplied.

Along with fertilization there should not be forgotten the importance of keeping the soil in good mechanical condition, especially in order that it may absorb and retain the greatest possible amount of moisture. Indeed, it is evident from the results of the Cudahy experiment, as well as from general observation, that this factor is much more important, at any rate for several years, than that of fertilization. To keep the soil in good condition applications of stable manure are very effective, likewise the growing and turning in of green manure or cover crops to as great an extent as possible. The latter practice, in southern California at least, is not as feasible with walnuts as with the citrus crop, since it is not practicable to plant the crop until after the walnuts have been gathered, which brings it quite late in the season. For a cover crop in walnut groves Canada field peas have been found one of the best in southern California, as they start quite readily during

the winter. In addition to stable and green manure, if other fertilizer seems desirable, we would suggest the application of tankage, or dried blood and superphosphate, either of which supplies nitrogen and phosphoric acid in an available but not too soluble form.

In fertilizing the walnut it is evident that comparatively large quantities of material must be used to obtain any real effect. The idea of applying a few pounds per tree of any substance with the expectation of producing some specific effect upon the tree or nuts is absolutely futile. With large trees we would advise not less than 50 to 100 pounds per tree of high grade materials, composed largely of fairly available nitrogen and phosphoric acid, if any real effect is to be obtained. This we would apply during the winter or spring at the time of plowing the grove.

PRUNING.

The pruning of the walnut tree in the orchard has not resolved itself into any such systematic practice as is the case with most fruit trees. In almost all of our present groves, in fact, no pruning at all is done, save that most growers usually go through each winter with an ax and cut off all the limbs which have come down upon the ground, in order to facilitate cultivation. There is quite a common impression that walnut trees should not be pruned any more than is absolutely necessary and that cutting in the top results in injury of some sort or other. One suggestive fact is evident with the walnut tree, however, namely that as the trees grow older and their tops closer together the setting of nuts through the interior of the tree declines very noticeably, and also that trees in outside rows or isolated trees which stand out by themselves produce decidedly more heavily than those in the interior of the orchard. This is especially noticeable in isolated dooryard trees, which are almost invariably heavy producers. These observations have led some growers to take out some of the inside limbs as the trees become older and more crowded, in order to maintain a better exposure to the air and sunlight. Such a practice is in our observation an excellent one and we would recommend in the case of large, old trees with crowded tops that a considerable amount of wood be taken out in the center of each tree in order to open them up. In young trees little pruning is ordinarily necessary, except that in very windy localities it may be necessary to keep pruning to some extent on the side away from the wind in order to counteract the tendency toward a one-sided growth. The walnut tree, except when influenced by wind, has a very strong tendency toward symmetrical development, regardless of the form in which it starts. If a large limb develops on one side during one year's growth this growth usually drops back the second year and the tree develops more rapidly on the other side,

bringing it back into a symmetrical form. It is, therefore, often better to let the tree take care of itself in this way, unless, as we have said, it is distorted by wind, rather than to try to balance it up by pruning. In case it is attempted to bring young walnut trees into symmetrical form by pruning, and likewise in forming the tops of top-grafted trees which have a tendency to become very top-heavy, better results seem often to be obtained by summer pruning while the trees

FIG. 22.—Santa Barbara Soft Shell seedling walnut grove in which the trees have never been pruned.

are in full growth and foliage rather than by cutting off limbs during the winter. In the latter case large, strong suckers are apt to come out at every cut and the shape of the tree becomes even worse than before. On the other hand, by cutting back the green shoots while they are growing their growth is decidedly checked, while those of other parts of the tree, being in an active condition, develop rapidly and produce the effect desired.

Figures 22 and 71 illustrate walnut trees which never have been pruned at all, the branches coming down upon the ground, which is the natural tendency of the tree. This practice is not without its advantages, although it is doubtful whether the latter are sufficiently great to warrant its general adoption. The walnut, like the lemon and orange and some other trees, seems to have a tendency to produce its fruit with particular abundance on branches close to the ground. It is certainly true that such branches are very prolific and produce more fruit proportionately than those higher up in the tree. For this reason some growers consider that the interference with cultivation by these low branches is more than counterbalanced by the increased crop obtained. This is largely a matter of personal preference, but in most orchards a higher-headed tree is to be preferred. In the young tree shown in Fig. 71 the object of the owner is to allow the trees to take this form during their early life in order to obtain quick returns, while as they grow older and higher it is his intention to gradually prune them up. Some growers may find it profitable to follow this method.

Another matter which may be discussed under the subject of pruning is that of the breaking off of large limbs of walnut trees, which frequently happens especially in the northern part of the State. The large lateral branches which develop from the main stems have a considerable tendency to form a very poor union in the angle of the crotch between the branch and the stem and many large limbs break off at this point. Trouble of this sort is much more common in the northern part of the State, possibly on account of the fact that the growing season is shorter and that during the rapid growth of the branches the crotch joints do not have time to properly unite. Where such large limbs break off nothing can be done but to make as clean a cut as possible at the point of breaking, and cover the wound with paint or grafting wax. One observation upon this subject is of value, namely, that in the walnut there are usually at least two buds, one above the other, at each axil, and of these the upper bud is the one which normally grows out, forming these branches which break off so readily. It has, therefore, been suggested that in localities where there is much trouble of this sort the upper bud at each axil where a limb is to be produced be cut off and the second bud forced into growth, with the idea that this lower bud will form a branch having a better union. There appears to be considerable value in this idea.

CROP HANDLING.

The following account describes the methods of handling the walnut crop most generally in vogue in southern California. In individual cases various deviations from the methods described are made.

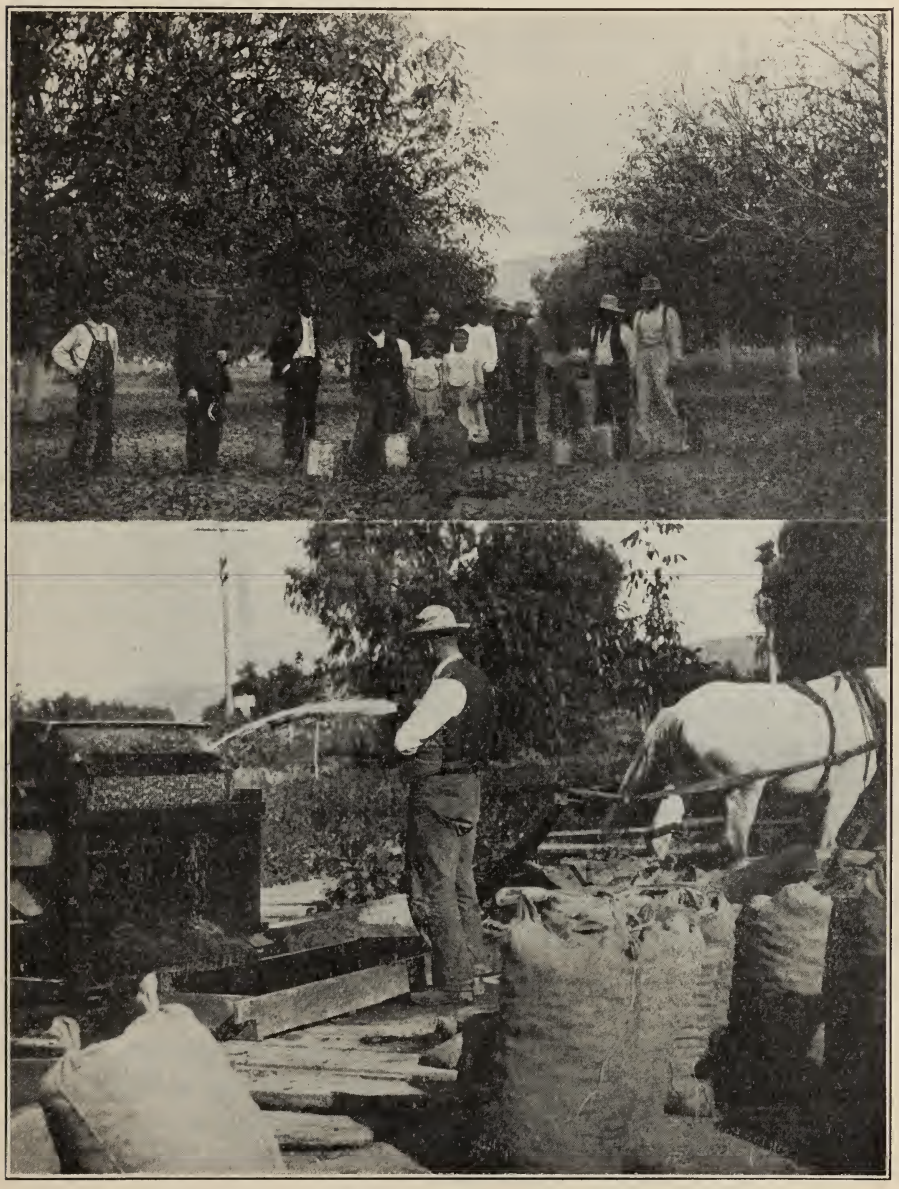


FIG. 23.—Top—Picking walnuts. Bottom—Washing; cylinder turned by horse power.

PICKING.

Walnuts are gathered by picking them up from the ground, where most of them fall naturally at maturity. When the nut is ripe the outer hull opens and the nut falls out in the majority of instances. The freedom with which the nut leaves the husk varies somewhat in different seasons, a greater proportion of nuts falling out more freely some years than others. Sticking of the husk to the nut is caused by sunburn, and also appears to be due largely to a lack of soil moisture, and to some extent to a dry condition of the atmosphere. In dry seasons, as a rule, the husks are more inclined to dry down tightly over the nuts rather than opening up freely while still green and succulent than in years of abundant rainfall. If this be true, the benefit of irrigation just previous to the ripening of the nuts is very apparent. The nuts are usually hurried off the trees to some extent by shaking, the latter operation being carried on by means of long poles with hooks on the end, by means of which the branches can be shaken without injuring the tree. In southern California walnut picking is done largely by Mexican families who camp in or near the groves during the season, while young and old of both sexes take part in the work. In some cases, however, growers are now employing able-bodied, adult labor for walnut picking, considering such labor more profitable on the whole than the cheaper class more commonly employed. Efforts have been made to perfect machines for picking walnuts from the ground by suction, but nothing of this sort has as yet come into practical use.

WASHING.

After being picked up and placed in sacks the nuts are carried to some convenient point and washed, in order to remove dirt, portions of the hull, etc., which may be sticking to them. Such washing is done in large, cylindrical drums made of coarse wire netting in which the nuts are slowly revolved under a stream of water, grinding against each other and against the wires forming the sides of the drum. In this way all the nuts which have fallen normally from the husk and those in which most of the husk has been removed by hand during picking are very thoroughly cleaned. For removing the more tightly attached husks of the sunburned nuts and "stick-tights" various devices are used, consisting in a general way of cylinders with sharp projections from the sides by means of which a considerable proportion of these nuts are cleaned up fairly well. There may still remain, especially during certain seasons, a considerable proportion of nuts with fairly good meat but with more or less of the hull tightly adhering to the shell. Such nuts are sometimes gone over again by hand, removing the husks which can be gotten off without too much effort, but

ultimately there always still remains a greater or less proportion of these "stick-tights" which must be picked out and discarded.

After these washing and other cleaning operations are over the nuts, now in a dripping wet condition, are placed in large trays having bottoms composed of slats spaced about one half inch apart, so that

FIG. 24.—Top—Drying nuts. Bottom—Delivering at packing-house.

the nuts may drain. These trays are commonly about 6 by 3 feet and 6 inches deep, thus holding several layers of nuts. The side boards are allowed to project at the ends and are shaped into handles for lifting the trays. In the trays the nuts are stirred, spread out in the open or stacked up and covered, according to the weather, with the

object of drying them as rapidly as possible without too great exposure either to the sun or to moisture. In the former case they are likely to split open, especially in poorly sealed varieties. In the latter they may become moldy and discolored. The larger and more progressive walnut growers, both north and south, are coming more and more to the use of artificial heat and enclosed buildings for drying their walnuts, rather than depending upon the uncertainties of the weather. In this way the nuts can be dried uniformly and quickly with no danger of exposure either to rain or hot sunshine. In the northern part of the State where early rains are more likely to occur and where later varieties of walnuts are more commonly grown, such artificial dryers are an absolute necessity in handling walnuts on a large scale and even in southern California they are coming into use. We will not take space to describe the details of such a dryer here but may say that a very large and complete one has recently been installed by Mr. J. F. Burgess of the Vrooman Ranch, Santa Rosa, which is well worth visiting to one contemplating such an apparatus.

After drying it is necessary that the nuts be graded to some extent at home in order to remove the culls and worthless nuts before delivery at the packing-house. For this purpose the nuts may be spread out again on trays or handled from sack to sack if working on a small scale, while on a larger scale an arrangement consisting of an inclined bin or runway large enough to hold several sacks or even several tons of nuts is desirable. In such a contrivance the nuts pass out at the lower end under the control of the operator, who picks out the culls and allows the good nuts to run into sacks, in which they are carried to the packing-house. Mr. C. B. Franklin of Carpinteria has an excellent arrangement of this sort.

PACKING-HOUSE OPERATIONS.

SAMPLING.

According to the methods commonly in practice in southern California the walnuts on delivery by the grower at the packing-house are first sampled for quality. The inspector picks out one hundred nuts here and there at random from the sacks and cracks each one to examine the meat as to fullness and color. There are various requirements as to quality, but usually nuts which crack from 80 to 90 per cent of sound, fairly-light-colored meats will pass. The standard varies considerably from year to year, according to the general quality and quantity of the crop and the condition of the market. Not over 10 per cent of badly shriveled or entirely bad meats is often accepted, while in color it is usually expected that 45 or 50 per cent must be white or

very light brown, and from 30 to 35 per cent amber, or not decidedly dark. Having been accepted by the inspector, the nuts then go to the bleach.

BLEACHING.

Various methods of bleaching walnuts have been practiced, the object being to remove all dirt and discoloration from the shells and give them a bright, light colored, attractive appearance. In the earlier years of the industry most of the nuts were bleached by exposure to the fumes of burning sulphur, this being done while they were wet. Sulphur bleaching is quite unsatisfactory, however, owing to the fact that the fumes penetrate the kernels of the nuts to a considerable extent and have a decided effect upon their flavor. On this account sulphur was largly abandoned several years ago and a process of bleaching the nuts by immersion in a liquid took its place. This process consists essentially in dipping the nuts into a solution of chloride of lime and sal soda, to which sulphuric acid is added, the result being a liberation of chlorin gas which brings about the bleaching action. The following formula which was given out by the University of California Experiment Station illustrates the details of this process: "Six pounds bleaching powder (also called chloride of lime), twelve pounds sal soda, fifty gallons water. Dissolve the bleaching powder in about four gallons of water, stirring till dissolved. Dissolve the sal soda in about four gallons of water. Add one solution to the other and stir well; let the carbonate of lime settle to the bottom and draw off the clear liquor and add water to make a total of fifty gallons. Put the nuts in large dipping box or lath crate, immerse in the fluid, and then add one and one fourth pounds of 50 per cent sulphuric acid and agitate by raising and lowering the dipping box. The bleach should be reached in five to ten seconds, and the nuts are then washed in clear water and put out to dry. Of course to employ this process cheaply, specially contrived dipping appliances are used. The same liquor can be used with new batches of nuts so long as the proper effect is produced, and small additions of acid will prolong the efficiency of the liquor."

Owing to litigation over the rights to this process and a decision in the California courts that it was covered by a patent, further efforts were made by the walnut growers to obtain a satisfactory bleach and quite recently they employed Professor Stabler of the University of Southern California, Los Angeles, to devise a new process. Professor Stabler brought into use the electric process, consisting essentially in passing an electric current through a 4 per cent solution of common salt by means of electrodes immersed in the liquid. In this process chlorin is set free and becomes available for bleaching. It is possible

also that the electric current may exert bleaching action of its own. At all events, walnuts bleached in this manner are decidedly free from the odor and taste of chlorin which characterized many of those bleached by the old liquid process. In the electric process, as first applied, the walnuts were immersed directly in the liquid through which the electric current passed. In its present, more improved form the apparatus consists of a comparatively small, porcelain jar or cell containing the electrodes, through which passes a continuous stream of the salt water which is mixed in a preliminary tank, passed through the cell for treatment, and goes on then into a storage tank. The bleaching device proper consists of a series of slightly sloping, superimposed narrow trays with coarse wire netting bottoms, down which the nuts are made to travel slowly by means of a shaking device. These trays are placed one beneath the other, the nuts dropping from the lower end of the first on to the upper end of the second, and so on, back and forth to the bottom. The electrically treated salt water is discharged in a fine spray over the top tray upon the nuts, and drops down through upon them more or less as they travel back and forth in traversing the various trays. At the lower end of the apparatus the nuts pass through a spray of clear water which cleans them of the salty solution. The whole apparatus is enclosed in a tight wooden box which assists bleaching to some extent by retaining the chlorin gas. This electric method of bleaching walnuts is still in process of development and improvement, but the results thus far obtained with it show clearly that it is far the most satisfactory method yet devised for bleaching walnuts. The nuts after treatment have a very beautiful, attractive appearance, without the dead, unnatural whiteness which is given to them by strong sulphur fumes and various other substances. The quality of the nut is seemingly injured not at all, as no odor remains after drying, while in respect to flavor there is also no objectionable effect. The only effect of this sort which can be detected is in the case of nuts which were partially open when passing through the bleach, which may have a slight salty flavor. On leaving the bleaching box the nuts are discharged on to a moving elevator belt which carries them into the grader.

GRADING.

In this operation the nuts are graded into two sizes, the first grade consisting of those which do not pass through an inch square mesh screen, while No. 2s are those which will pass through such a screen but not through a three quarter inch square mesh. Various devices for grading are in use, some consisting of a cylindrical cylinder with sides composed of a wire screen of the proper mesh, while more commonly they are graded over a horizontal screen which is shaken back

and forth by machinery so that the smaller nuts drop through, and all sizes are carried automatically on to belts which elevate them into bins for drying and storage. In some houses artificial drying is resorted to at this point, since in a moist climate or in wet weather the nuts may become moldy and discolored before drying. More or less grading for quality is done after the nuts leave the bleach by picking out discolored or otherwise objectionable nuts by hand at some convenient point in the operation. The nuts which are simply discolored, but still contain good meats, are sometimes run through the bleach a second time and considerably improved in appearance. From the final bins the nuts are drawn off into large sacks containing about 100 pounds each for shipment to market.

WALNUT GRADES.

The commercial grades of walnuts commonly made in California are as follows: "Budded," No. 1 Soft Shells, No. 2 Soft Shells, No. 1 and No. 2 "Standards" or "Hard Shells," "Paper Shells" and culls. The term budded walnuts, as commonly applied in the trade, includes the Placentia Perfection, or nuts of equally good appearance graded over a screen one and three sixteenths inch square mesh. Into this class go all the good-sized nuts of any desirable variety which is worthy of propagation by budding or grafting. These usually command a premium of two or three cents per pound over the best of the ordinary nuts. The terms Soft Shell, Hard Shell and Paper Shell are of rather uncertain meaning so far as the thickness of the shell is concerned. As a matter of fact, very few or no No. 1 Hard Shells go on to the market, but almost any good-sized nut is classed as a Soft Shell.

"Hard Shell" and "Paper Shell," so far as they have any definite meaning, refer commonly in southern California to certain types or varieties of trees rather than to nuts of a particular thickness of shell. "Hard Shell" means commonly the old-fashioned walnut of the first California plantings, which is a tree of quite characteristic type. The bark is of decidedly whitish color, the general form of the tree rather stocky and compact, while the nut is small, quite round and decidedly hard-shelled. The tree is less thrifty and more inclined to die-back and deterioration than the prevailing type of the soft-shell tree. Comparatively few of these typical hard-shell trees now remain in the southern California groves. Any good nut of desirable size and shape goes on the market as a soft-shell, regardless of its actual cracking quality, so that extreme thinness of shell is not a necessary or even a desirable quality. Any good-sized, slightly elongated nut is decidedly better from a commercial standpoint for having a comparatively hard, not easily opened shell, since such nuts stand handling better and are also less liable to the trouble called perforation, which we describe elsewhere.

The term "Paper Shell" also denotes a certain, quite characteristic type of tree rather than referring to any or all nuts with unusually thin shells. The Paper Shell of southern California originated almost or quite entirely among the earlier trees propagated by Joseph Sexton of Goleta. These trees are of quite distinctive character, being of small size as compared to soft shells or even hard shells of the same age, with a slender, white barked trunk, rather large leaves, compact top, and a small, round, more or less thin-shelled nut. Some typical Paper Shell trees, however, bear nuts which are not especially thin-shelled and all degrees of gradation may be found between paper shell, soft shell, and hard shell trees. The typical Paper Shell is quite similar to the French variety Chaberte in many ways. Most paper shell trees are particularly susceptible to walnut blight and the variety has nothing whatever to recommend it.

SELLING.

The walnut growers of southern California are quite generally united into coöperative associations, each with its own packing-house and officers. The members of each association carry their nuts to their packing-house, where they are handled and sold by coöperative methods. In addition to these various local associations the whole industry is organized rather loosely into one general organization for certain lines of business. The directors of the local associations hold a combined meeting at least once a year and keep up a general organization, having a president and the other usual officers, including a paid secretary. Matters of general interest come before this larger meeting, including the purchase of sacks for each season, and particularly the fixing of prices for each year's crop. At a meeting held each year early in the fall, reports and estimates are submitted as to the probable crop of the season and minimum prices are fixed for nuts of the various grades for that year. The actual selling is then done through outside brokers who receive a commission for their services. This method of selling is not altogether satisfactory with many growers at present, and the suggestion is frequently made that the general association employ its own agents in the various trade centers all over the country to sell the crop along the lines practiced by the California Fruit Growers' Exchange, which handles the bulk of the citrus crop.* Growers who are not affiliated with any association usually sell their nuts directly to brokers or commission men and commonly receive association prices for the same. A few growers, especially in the northern part of the State, whose orchards are composed of grafted trees of the better varieties, have a special trade of their own and receive from 20 to 100 per cent more for their nuts than the ordinary prices. The

*Since the above was written an incorporated central association has been formed along these lines.

prices received by the southern California associations during the past few years have ranged between 12 and 15 cents per pound for No. 1 soft shells, about 1 cent less for No. 1 hard shells, and about 3 cents less for No. 2s than No. 1s. Some income is also derived from culls, which, if fairly good, may bring at least 5 cents per pound, and also from the selling of meats which are removed by hand from the broken or very poorly sealed nuts. The grower usually receives about one cent less per pound than the fixed price, this difference representing a portion of the broker's commission and packing-house expenses. The remainder of these expenses is covered by a small profit made by the associations on the sacks, which are bought through the general association at very low rates.

PROPAGATION OF THE WALNUT.

In starting a walnut orchard various methods of procedure are possible, all of which have their merits and their enthusiastic supporters. Of these methods the three following are most important: Planting the nuts in place in orchard form for subsequent grafting when the trees are large enough; planting nursery-grown seedlings in orchard form for subsequent grafting, and the use of nursery-grafted trees for orchard planting.

ROOTSTOCKS.

Inasmuch as various roots upon which to grow the English walnut are available, it is not to be expected that any one species will necessarily be the best under all conditions. It would rather seem reasonable that the walnut, like most fruit trees, would do better on some soils or under some conditions upon one kind of root, while under other conditions a different root would be most suitable. In the case of the walnut much still remains to be done in regard to testing various roots. The planting of grafted trees is so recent that very little careful testing has been done and in the majority of cases it is only known in regard to the root that they are "English" or "Black," the latter including all sorts of forms. After discarding the English root, which nurserymen have now done quite universally, they have in most cases simply gathered nuts from the most convenient black walnut trees, and thus we have among the so-called black walnut roots both the northern and southern California species, some straight eastern and many hybrids of various mixtures and generations. It is therefore possible to tell very little from existing plantings as to root, since it would be necessary to know the particular tree from which certain seedlings came in order to duplicate them. A few of the most advanced nurserymen have commenced in recent years to segregate seedlings of the various species, hybrids, and those from certain individual trees, and it is only in this

way that roots can be definitely tested on different soils and in different localities with any possibility of duplicating the same roots after their qualities have been determined.

In our own work the necessity of testing rootstocks as well as different varieties of the nut itself was recognized from the first, and in the planting of our experimental orchard on the Whittier State School grounds, an effort was made to obtain trees of the various varieties on as many different roots as possible when the first planting was made. We soon found, however, that the roots of these first trees purchased from various nurseries came a long way from representing definite species or types, but that as a matter of fact they were a very much mixed lot. After commencing propagation of our own, root-testing was still kept in mind, and further plantings for this purpose have been made. We have now trees growing on various types of soil in various parts of the State and on different, definitely known roots, from which plantings results of some value can be looked for. A few other propagators are doing the same thing. Experience has abundantly proven that on account of the extreme variation in the seedlings of various black walnut trees and the freedom with which trees hybridize or cross with any other walnuts in the vicinity, the matter of rootstock must come down to a determination of the qualities of the seedlings of certain individual trees rather than those of all the trees of any given species or form.

The general requirements in a root are that it should produce a thrifty and vigorous tree, the more so the better, under as many different conditions as possible. In other words, it should be one which is not easily affected by unfavorable conditions, but which will produce and maintain a good, thrifty tree even if the ground is a little too dry or too wet, and upon as many different types of soil as possible. Having a large variety of types to choose from, however, it is not to be expected that any one root will be the best under all conditions but rather that we shall ultimately find one type to be the best for dry soil, another the best where there is an excess of moisture, one for heavy soils, one for light soil, and so on. At the same time a good all-round root or one which is not easily affected by any variation from its favorite condition is by far the best for general purposes. It is not impossible that we shall ultimately find a difference in regard to varieties of the English walnut as to root, some kinds doing better on one root and others on another. There is already some evidence that this is true. From the nurseryman's standpoint, it is desirable that a type be chosen for the root wherein the parent tree is a large producer of nuts, one in which the nuts germinate readily and uniformly, producing a uniform lot of seedlings with a good affinity for the English walnut.

The nurseryman growing any considerable number of trees cannot afford to run about picking up a few nuts from a tree here and a tree there, even though they may give seedlings of unusual excellence. Having found good trees from which to propagate, some nurserymen are coming to the practice of reproducing a considerable number of these trees by grafting and planting them out on their own grounds for seed production purposes.

English Walnut Root.—The propagation of the English walnut upon its own root has been almost entirely abandoned in California. This is on account of the fact that this root, while very vigorous and thrifty under perfectly favorable conditions, is easily affected by adversity and very susceptible to unfavorable conditions, either permanent or temporary, such as dryness, excessive moisture of the soil or any other condition not perfectly favorable. The English root delights in a deep, fertile, well drained, fairly heavy soil, with uniform and abundant moisture, and under such conditions trees grafted upon it are thrifty and vigorous, but experience has shown that comparatively slight variations, such as dry years or other influences, react very quickly and unfavorably upon trees on this root. The root is also more susceptible to crown gall, gophers, root rot and some other injurious influences than are those of any of the black walnuts. For these reasons propagation upon the English root is practically obsolete in California.

Eastern Black Root, Juglans nigra.—This root has been tried to some extent in California, but the species is of such extremely slow growth in this State as compared with other black walnuts that it can scarcely be considered as a commercial root for general use. The impression is general that this root is better adapted to wet land than any other, on account of the native habitat of the tree in river valleys. Even under such conditions, however, it is probable that for use in California a better root can be chosen for planting in any soil which is worthy of consideration for walnut culture.

Northern California Black Root, Juglans hindsii.—The black walnut of northern California is an extremely thrifty, vigorous tree under most conditions at all favorable to tree growth, and this is one of the most popular and satisfactory roots for the propagation of the English walnut. For general use, where no special study of selection of rootstocks is made, it is probably the best root which can be recommended for California planting. It should be remembered, however, that the progeny of various individual trees of this species vary greatly, and the seedlings of some trees are much more uniform and much better trees than those of others. Indiscriminate planting of northern

California black walnut is, therefore, not advisable if the grower desires to produce the best possible trees upon this root. It is much better to plant separately the nuts from various trees and determine the nature of the offspring in each instance. Only trees of large production should be chosen for this purpose, since it is not profitable to gather nuts here and there from a great many different trees. Seedlings from the best types of the northern California species produce, when worked to the English walnut, a thrifty, vigorous tree, of very good growth, more resistant both to excessive moisture and drouth than those upon the English root, not susceptible to gophers or root rot, and in every way a very good, all-round tree. The root is only excelled by certain special hybrids which will be discussed later.

Southern California Black Walnut Root, Juglans californica.—This root has been quite commonly employed for the English walnut in the southern part of California and has much to recommend it, particularly for that part of the State where it has been most tested. The quite common impression that the southern California walnut root has a dwarfing effect on trees worked upon it is entirely erroneous, as such is certainly not the case. The tree no doubt gets this reputation from the fact that as it grows wild on dry hillsides it often has a dwarfed, shrubby form. When planted in good soil, however, with even a moderate supply of moisture, it is a tree of extremely rapid growth, especially in diameter, and actual experience shows that with trees upon this root there is no indication whatever of a dwarfing effect. In our southern California nurseries we have found no walnut which gives as uniform a growth of seedlings in the row or as uniformly good grafted trees during the time that they are in the nursery as this. From the nurseryman's standpoint, in the south at least, it is an ideal tree, the nuts sprouting early and uniformly and the seedlings making a uniform, vigorous growth kept up until very late in the fall. Trees of this species remain green and still growing while the northern California and other forms have become dormant and dropped their leaves in the fall, while in the spring they are the first to come out. The tree is, therefore, especially good for budding on this account. The southern California walnut unites readily with the English, and, as we have said, for the southern part of the State at least, we believe it to be one of the best roots. Other objections to this root have been that it is especially susceptible to wet land and also that trees grafted upon it are more apt to blow over than those upon other roots. The first objection is not without foundation, since the southern California walnut, from the first sprouting of the nut, is extremely susceptible to an excess of moisture. This root should not be used for trees to be planted on very heavy land which is likely to be extremely wet at times.

We should, in fact, hesitate to use the southern root at all for the northern part of the State, except on decidedly light soil. One should also not attempt to grow it in a nursery where the soil is heavy and wet. In this connection see seedling root rot, or wilt, page 379, a decay of the root of seedlings in very wet or heavy soil. This trouble seems to be limited to this species. The matter of the trees tipping over is not usually a very serious objection, although such trouble does seem more common on this root than on any other. There is some experience available which seems to indicate that for late varieties like Franquette and Eureka, the southern black walnut root is not quite as well adapted as for early varieties like Placentia, Chase, or Prolific. With the latter

Fig. 25.—Ten-year-old Placentia tree on southern California black root.

it certainly makes a magnificent tree, as shown in many existing orchards. Even with the late varieties it makes an unusually fine tree, in the nursery at least, and the most uniformly large and the best stands of Eureka which we have ever grown were on this root.

HYBRID ROOTS.

The remarkable vigor and rapidity of growth of some walnut trees of hybrid origin such as we have described elsewhere has led to the very natural inference that seedlings of such trees should be extremely desirable as a rootstock for the English walnut. Working on this idea, we have experimented with such roots quite largely during the past five years and several other investigators have done the same.

Paradox Hybrid Roots.—It would seem at first thought that seedlings of some of the very large, wonderfully thrifty Paradox hybrid walnut trees found in California should give an ideal root for the

FIG. 26.—Four-year-old Placentia tree on Paradox root. Trees shown in Figs. 27 and 28 in the background.

English walnut. In order to test this, nuts from many of these trees have been planted by ourselves and others, the resulting seedlings

grafted to various varieties of the English walnut and the trees planted out for observation. We may say, however, at the outset, that such trials have resulted without exception in proving the non-desirability

FIG. 27.—Four-year-old Placentia tree on northern California black root.

of the seedlings of these Paradox trees as a rootstock for the English walnut. Trees on this root are invariably lacking in any unusual vigor

of development and these second-generation Paradox seedlings may therefore be dropped out of consideration.

The next question which suggests itself is the possible utilization

Fig. 28.—Four-year-old Placentia tree on English root.

of first-generation Paradox trees; seedlings, in other words, which come directly from black walnuts which have been cross-fertilized with pollen of the English walnut. Such trees, as we have shown elsewhere,

occur in a greater or less proportion among the seedlings derived from black walnut trees which stand in the vicinity of English walnuts. These seedlings are those which grow into the extremely vigorous trees seen here and there in the State and it is certainly to be expected that an English walnut upon such a root would have some unusual vigor. This we have found to be the case, by grafting upon the hybrids which appear here and there among the black walnuts and by planting out such trees for future observation. We cannot yet say that every tree upon a first-generation Paradox root will have this unusual vigor but so far as our observation has gone such trees have a general tendency toward such a habit. Figs. 26, 27 and 28 illustrate a case of this sort, these being Placentia Perfection trees grafted at the same time, of uniform size when planted in the orchard and planted adjacent to one another under uniform conditions. The tree on the Paradox root in Fig. 26 is fully twice as large as the one upon the English root, and decidedly larger than the one upon northern California black. That the production is proportionate to the size is shown by the crop of 1911, when the Paradox root tree produced 18½ pounds, that upon California black 12½, and that upon English 9 pounds. English walnut grafts unite readily with the Paradox root, which is a very desirable feature from the nurseryman's standpoint. It is not probable, however, that this root will ever be largely used by the general nurseryman, since only a comparatively small and very uncertain percentage of hybrid trees develops in the nursery, extra work and care are required to keep separate the trees on these roots from those on the straight black and only one who is something of a specialist and who is able to make a special effort to obtain and segregate these roots can expect to make a regular practice of growing trees upon them. For such trees he must obtain a greater price than that received for those on ordinary roots, in view of the extra expense and care necessary to produce them. Good Paradox roots are especially well adapted to light, dry, or rather sandy soils, as this hybrid is particularly vigorous under such conditions as compared to any of the ordinary walnuts. On the other hand, trees of the same nature have sometimes shown themselves likewise resistant to an excess of moisture. It is, therefore, likely that the exceptional vigor of this root enables it to withstand any unfavorable condition to a considerable extent. It is to be expected, theoretically at least, that Paradox trees containing eastern blood would be better for wet land than those consisting of English and California black. Much remains to be done, however, in testing out various combinations and especially in testing the seedlings of various individual trees under various conditions. The whole question of the value of hybrid roots is indeed one concerning the progeny of individual, special trees

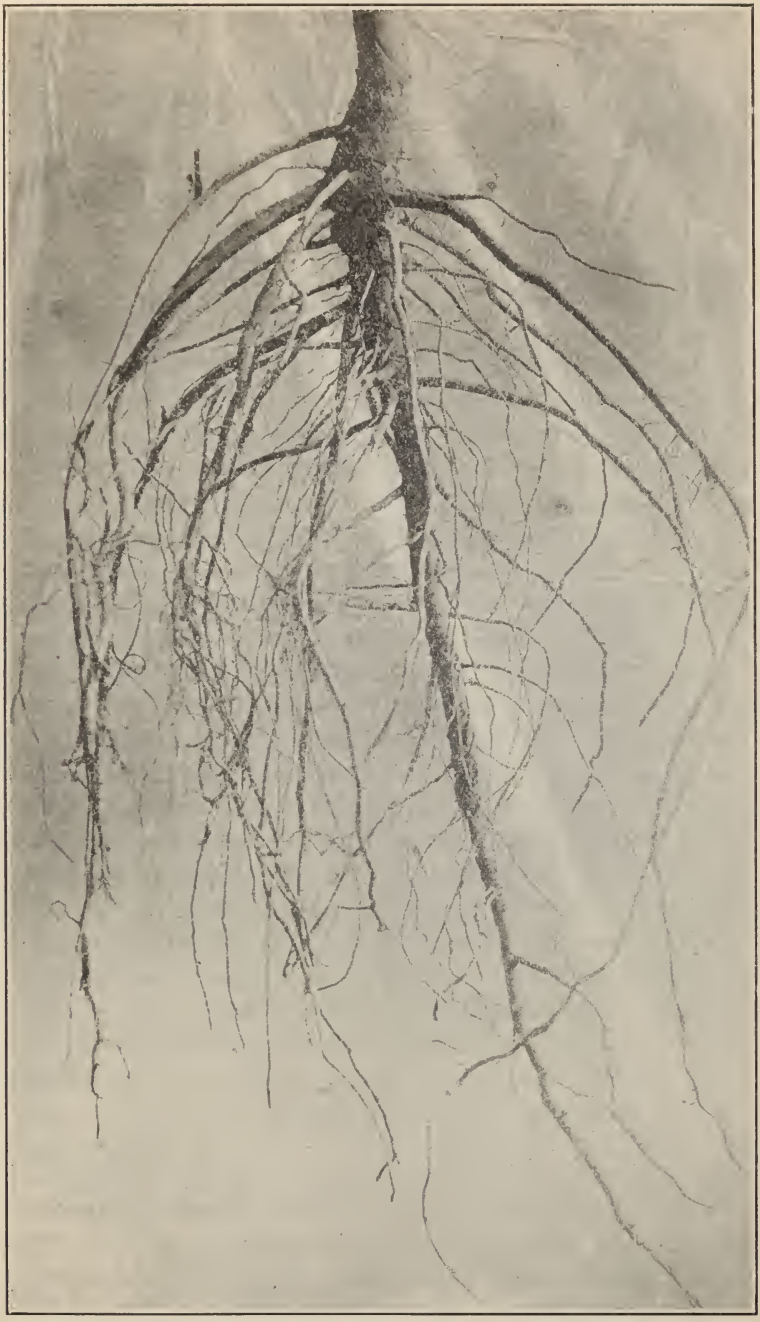


FIG. 29.—A good Royal hybrid root; one year old. Southern California x Eastern black.

rather than a matter of any general rules applying to all crosses between certain species.

Royal Hybrid Roots.—Here again we enter the domain of the specialist rather than that of the average, commercial nurseryman. We have stated elsewhere that in the Royal hybrid (the cross between California and eastern black walnuts) many very thrifty, vigorous trees occur and that this vigor is carried over into the second generation much more than in the Paradox. In other words, experience has shown that while seedlings from Paradox trees do not have the exceptional vigor of the parents, there are some first-generation Royal trees which transmit their exceptional rapidity of growth to their progeny of the second generation. These trees vary greatly, however, in regard to the character of their seedlings and it is only a very few which produce nuts that give a uniform lot of seedlings as good as the parent. Such trees, when found and thoroughly tested, are extremely valuable. We wish again to emphasize the fact, however, that indiscriminate planting of nuts from Royal hybrid trees cannot be expected to give uniformly good seedlings for grafting purposes but rather will result in a most heterogeneous mixture of trees of all sizes, characteristics and degrees of vigor. The Royal trees found growing about the State are of various generations, many of them of the second generation, of which the seedlings are decidedly inferior, and the nurserymen would do better to plant the nuts of the straight northern or southern California black walnut than to pick up Royal nuts at random. The propagation of English walnuts on the Royal root with the idea of getting trees of marked superiority over those grown on the California species is again, as in the case of the Paradox, the work of the specialist who is disposed to try out individual trees carefully as to the nature of the seedlings and that of trees grafted upon them, a process which takes several years in the case of each individual Royal tree thus tested. Trees of real excellence upon this root must also, therefore, be grown by the specialist and command a considerably higher price than ordinary trees. It should be equally understood that really select trees on these exceptional roots constitute the very acme of perfection in walnut trees as to vigor and hardiness, that they can be produced only by the exceptional nurserymen and probably they will be purchased only by growers who are willing to pay a premium in order to obtain an exceptional orchard. Trees upon well-grown roots of either of the ordinary California species are thoroughly good and first class, and need not be deprecated on account of the fact that it is possible to grow these exceptional trees to a limited extent on properly selected and tested hybrid roots. Indiscriminate trees of the latter class, it should also be understood, are no better than and perhaps inferior to those of

the former nature. The best Royal hybrid roots, in addition to giving trees upon them of exceptional vigor, are also particularly adapted for planting on rather wet, heavy soils on account of the blood of the eastern black walnut which they contain. Well tested Royal roots are probably the best for such soil. On the other hand, the vigor of the best Royal root enables them to also do well on dryer soils or without irrigation, so that they have a wide range of adaptation.

PLANTING THE NUTS IN PLACE.

A few years ago a very popular idea prevailed, especially in the northern part of the State, that the only proper way to plant a walnut orchard was to start black walnut seedlings directly from the nut in the spots which the trees were to occupy in the orchard, so that these seedlings could be grafted to the desired variety of the English walnut later on without ever disturbing the taproot by digging and transplanting. In order to insure a good tree in each place, instructions were given to plant about five nuts close together, like a hill of corn, at each point where a permanent orchard tree was to stand. Out of these five it was assumed that at least one would make a good tree, and that this could be allowed to remain, while any others were to be removed. A considerable acreage was planted and is still being planted in the northern part of the State by this method. Its apparent cheapness is attractive, and the idea of not disturbing the root has also appealed to many quite strongly. In practice, however, we may say without reservation that in no instance do we know of this method proving practical or satisfactory. The objections to it are as follows: In the first place, even though five or more nuts be planted in each place, there are always in a large planting some hills where for one reason or another no trees develop. Some will produce five good trees, others none at all, and others one or more poor trees which do not become fit to graft. In some of the hills very thrifty, rapid-growing trees will develop, while in others the best tree will be of poor and slow growth and thus at the end of the first year the planting will consist of trees of great variation in size, with now and then a place where there is no tree at all. This variation in the growth of the trees becomes greater and more pronounced as years go on. Furthermore, in planting by this method, which presupposes that it will be a number of years before any walnuts will be produced, some other crop is ordinarily grown on the land in the mean time, and in cultivating this crop between these little seedlings it is impossible to avoid a tree here and there being run over, stepped on, or destroyed in one way or another. Again a rabbit or squirrel may get one, some insect pest another, and so the irregularity of the planting becomes more and more

pronounced. Again, it is impossible to give to trees planted out in the field in this way the care which could be given them if planted in the nursery, and their growth at best is much slower than it would be under the latter conditions. When the best trees finally reach grafting size, there are bound to be many others in the orchard of all sizes and ages which struggle along over three or four years before they get large enough for grafting. After grafting commences the same irregularity continues. In some trees the grafts do not take the first year, consequently these must be grafted over again the second and often even the third year. Thus the whole tendency of this method in practice is to produce a most irregular, uneven orchard, and at the same time requiring several more years for its development than is necessary under other methods. More than all this, the absolute fallacy of the notion that there is any disadvantage in cutting the taproot or in transplanting the walnut tree has been abundantly established, so that the only object of using this method loses completely its value.

PLANTING BLACK WALNUT SEEDLINGS IN ORCHARD FORM.

This method represents a decided improvement over the last one. It consists in growing black walnuts of the desired type in the nursery, then selecting from these as good and uniform a lot as possible and planting them out, ordinarily when one year old, in permanent orchard form, with the idea of grafting them later on. By doing this several of the objections to the last method are overcome. It is possible to get a very uniform stand of black walnuts, provided the stock is of uniform nature, and by proper selection of seedlings, trees can be obtained which will come along fairly uniformly and be ready for grafting at about the same time. The advantages claimed for this method are mainly two: first, that by allowing the black walnut trees to reach considerable size they may be grafted at a height of about five feet, thus obtaining a black walnut rather than an English walnut trunk, which, with its rough bark, will be more immune to sunburn. The second advantage is that in planting an orchard to be grown without irrigation, grafts upon a well established black walnut tree will be much better nourished and receive a better supply of moisture during the first year or two, when a transplanted tree would be using up its energies in developing new roots, and thus the high-grafted tree will obtain a much better start. Both of these ideas have considerable merit, especially in planting where irrigation is not to be practiced. Under such conditions a vigorous black walnut seedling, especially if dug with a good root and cut back in the top, as described on pages 245 and 248, may usually be established without much difficulty by a little hand-watering during the first season. If the soil is such that non-irrigated orcharding is at all feasible, the tree will then go on to

vigorous development in subsequent years. A nursery-grafted tree, if planted at the same time, and especially under rather dry conditions, is likely to fall behind the black walnut seedling and never catch up to it again in growth. After three or four years the black walnut may be cut off and grafted high, whereupon its large, vigorous root will furnish the grafts with an abundant supply of moisture and force them into rapid development. There is also some advantage in regard to sunburn in the black walnut trunk, although we have seen such injury even to the black walnut on rather dry soil. It is also true that sunburn is not apt to prove serious with properly grown English walnut trunks on good soil.

The method of top-grafting black walnuts in place is open to one objection in common with that of planting the nuts in place, namely, that after grafting commences a uniform stand cannot be obtained the first year, and the work will probably extend over at least three years before all the trees bear a good top. In this way the orchard becomes irregular and uneven. Again, it is objected with considerable reason, that in this high grafting on trees several years old, very thrifty, rapid-growing shoots develop from the grafts, which become extremely topheavy, easily blown over by the wind, and a source of real difficulty to keep up in shape until they are able to support themselves. On this account there is now a tendency to graft low on such trees, within two feet of the ground, even though most of the supposed advantage of the black walnut trunk is thereby lost.

Altogether, we may say that if the walnut orchard is to be planted in good soil with irrigation, the disadvantages of this method over planting nursery-grafted trees by far outweigh its advantages. At best it is slow in producing a bearing orchard, it results in much irregularity in the size and growth of the trees, the tops are very difficult to support, and, under the conditions mentioned of good soil and moisture, there is no real advantage in the end to offset these objections. In planting a walnut grove to be grown without irrigation, especially on rather shallow dry soil, where the trees at best may have a rather scanty moisture supply, this method in spite of its disadvantages is probably the best one to use. In following it extra good, one-year-old seedlings of the best kinds should be obtained, these to be treated for planting by digging with as much root as possible and cutting the tops back severely, as described on page 248, planted out early in the winter so that they will obtain all possible benefit of the winter rains, and given all possible care during their first season's growth. A good-sized circle should be kept cultivated or hoed about each tree, they should be given a copious watering by hand as many times as possible during the first season, and it is well to dig into the soil about them a

good dressing of stable manure with a heavy mulch of the same material, in order to retain moisture as well as add fertility to the soil.

As the trees grow they should be staked up if necessary and trained to a single stem which eventually should be cleared of side branches up to about five feet. It is not, however, necessary or desirable to prune the tree to a single, bare shoot from the very first, since side branches shade the trunk from the sun and also assist in growth, particularly that in diameter. It is, therefore, better to take off the laterals gradually from below at the end of each season rather than keeping them all cleaned off continuously. For the best success of this method it is not well to hasten the grafting too much, as better permanent results will be obtained by allowing the trees to reach considerable size before grafting. Grafting when the trees are less than three inches in diameter at a point five feet from the ground is of doubtful advisability, and it is better to wait until most of the trees in the orchard have reached at least this size before commencing grafting. It is not advisable to graft each year a few of the largest trees, thus scattering the grafting over several years, on account of the unevenness of an orchard treated in this way. For methods of top grafting, see page 230.

RAISING THE TREES IN THE NURSERY.

This, as we have shown in discussing other methods, is ordinarily much the most satisfactory and successful, and the quickest and cheapest method of starting a walnut grove.

SEED TREATMENT.

Walnuts to be used for planting in the nursery should, after gathering, be kept in sacks or other receptacles in a cool, not too dry place until planting time. If allowed to become extremely dry after gathering the nuts germinate much less easily than otherwise. They will usually keep in good condition if tied up in sacks and piled in a cool, shady place. It may be found desirable to allow the outer hulls to dry somewhat before sacking up the nuts, especially in the case of large hybrid nuts, since if sacked and put away quite green the hulls decay and become extremely soft and mushy. Early in the winter, not much later than January, the nuts should be layered in sand or light strawy earth in order to sprout them and segregate the best ones from those that germinate feebly or not at all. This is most conveniently done by constructing a frame about 18 inches deep, either above or below ground, in the bottom of which should be placed 3 or 4 inches of sand, then the layer of nuts which may be either one or several nuts in depth, according to the available space. The nuts are then covered with 3 or 4 inches of sand, which should be washed down thoroughly between

the nuts by means of a stream of water. The whole bed will thus be in a well-soaked condition by the time it is done. Instead of placing the nuts directly in the bed, it is more convenient in getting them out to put them in shallow wooden boxes or flats, imbedding these in the sand as above described. If this is done it is much easier to get the nuts out for planting than if they are placed directly in the sand. Other materials may be substituted for sand, such as earth mixed with fine straw or manure, or any substance which holds moisture well, and from which the nuts can be easily removed. The bed should be so arranged that water will drain away from it and not accumulate sufficiently to rot the nuts, and it should be protected from rain if there is any danger of such an effect from that source. The nuts need to be constantly well moistened, however, in order to start germination, and if drainage is good there is not much danger of getting them too wet. The bed should be located in a place where it will receive the heat of the sun in order that it may not be too cold for germination, and it may be underlaid with manure if it is desirable for any reason to hasten the sprouting of the nuts. Nuts of the different species vary quite widely in respect to freedom of germination, those of the southern California black walnut being especially quick to sprout. These also rot more easily than other black walnuts. They need not, therefore, be put into sand so early and should not be kept as wet as northern California blacks or Royals. The latter especially need much moisture and warmth to make them sprout. For prompt and uniform germination they should be put into the sand quite early, in a single layer of nuts, and be kept well moistened and as warm as possible. Otherwise many will not sprout until the second or even third year, if they be put into the ground before starting to germinate.

As soon as a considerable portion of the nuts has begun to sprout in the sand bed they must be gotten out into the nursery as soon as possible. In preparing the nursery ground special care should be taken, as the growth of walnut seedlings is very easily affected by slight differences in soil conditions. The ground should be prepared in the fall by thorough and deep plowing and cultivation, in order that it may be loosened up to as great a depth as possible and brought into a fine, mellow condition, free from lumps and with no hard layer of soil near the surface. A soil free from rocks, hard, unbreakable lumps or shallow hardpan should be chosen for the nursery if one expects to grow good trees. Greater growth is obtained on a fairly heavy soil, although the heavier the soil the more difficult it is to work. The future digging of the trees should also be considered, as this is a question of importance in connection with the nature of the soil. A somewhat sandy soil is easier to handle and much more convenient for

getting out the trees when ready for market than a heavy soil, as the latter is likely to be muddy and unworkable at the time when the trees should come out. Larger trees, however, are grown on heavy soil and big trees commonly bring the best prices. By means of fertilization and an abundant use of water, the growth of trees on lighter soil may be accelerated to a considerable extent. Walnut nursery trees are grown more or less without any irrigation at all in the northern part of the State, but under such conditions only a fairly heavy soil with strong water-retaining properties should be considered.

In planting the nursery, rows about three feet nine inches apart should be furrowed out with a single plow, and the best sprouted nuts may then be planted at a distance of from nine to twelve inches apart in the row. Particular care is desirable at this point, placing the nuts carefully in place by hand with the sprout pointing straight down rather than dropping them in indiscriminately regardless of position. In practice it will be found that some of the sprouts have made several inches growth before planting commences and these should be handled carefully and planted with a trowel. It is well for the planter to carry such a tool in one hand, filling up the low places in the furrow, digging holes for the longer sprouts and planting each nut as carefully as possible. In some cases, on account of rainy weather or other reasons, it is impossible to start planting early enough and many of the nuts will form long sprouts and commence sending up a stem before planting. These can still be planted out, although the work requires more care. Root sprouts which are several inches or a foot or more in length usually become broken, but will still grow successfully if not broken off close to the point where they come from the nut. It is indeed advisable to cut back long sprouts to a length of a few inches rather than attempting to preserve each one and dig a deep hole for it. Such trees will often form a large, branching root, more desirable than one produced by the uninterrupted growth of the original tap root. If the upward-growing sprout be broken off the nut should be discarded. It may sometimes be necessary to go over the bed two or more times in order to get all the good nuts out before the earliest have made too much growth. For growing the best trees, however, only the nuts which germinate most promptly and vigorously should be used, and it will be found necessary to discard a considerable percentage of the nuts placed in the sand. After planting, the nuts should be covered to an average depth of about three inches, which may be done with a single plow, if the nursery is large, going over the ground afterwards with a harrow in order to smooth over the irregularities and even-down the ridges. Special care should be taken not to plant too deep.

If the nuts have been well sprouted, the seedling trees will soon begin

to appear above ground, although if heavy rains occur before this time the surface may crust over, especially on heavy soils, to such an extent as to make it difficult for the young sprouts to break through the surface. Under such conditions it may be well to go over the nursery with a rake or light harrow in order to break up this crust. As the trees grow they should be given good care, such as would be given to a crop of corn or potatoes, by frequent cultivation and hoeing. Seedlings are grown without irrigation in some localities, and there is a fairly common impression that such trees are more hardy and desirable than those grown under irrigation. We cannot coincide with this view, however, having found no undesirable features in irrigated trees, while their superior growth is desirable from every standpoint. As ordinarily grown without irrigation, two seasons' growth is necessary to get the majority of the seedlings up to sufficient size for grafting, while with good soil and abundance of water, fine large trees of ample size for grafting can be produced in one year, with roots proportionate to the top in size and with no undesirable qualities whatever on account of having been given sufficient moisture for their best development. The difference, in fact, is fully as apt to be in the other direction, non-irrigated trees being stunted and reaching grafting size only after several years' growth. Again, in unusually dry years, non-irrigated trees may be badly injured or even killed by drouth.

GRAFTING.

With good care and sufficient moisture the majority of the seedlings should reach sufficient size for grafting during their first year's growth and be ready for grafting during the next winter following that when the nuts were planted. The size of tree which is suitable for grafting depends largely upon the size of the scions available, since seedlings can be used nearly down to the size of the smallest good scions. In practice it will be found that trees of from one to two inches in diameter close to the surface of the ground are best adapted for grafting, while with the best of the smaller scions trees down to that of three quarters of an inch or a little less may be used. This assumes that the trees are grafted close to the ground.

There are various methods of nursery walnut grafting in practice, the majority of which we will not attempt to describe. The operation at best is one which requires much skill and practice, the walnut being less easily grafted than most fruit trees, and among those who are doing the work successfully each has his own method to which he has accustomed himself by long use and which might hold no particular advantage for the beginner. We will, therefore, describe but one method of nursery grafting, which is that which has proven most successful with us.

Time of Grafting.—The time most commonly chosen for grafting walnuts in the nursery is the period just before the seedling trees commence growth in the spring, or even after the buds have unfolded and the leaves developed to some extent. Various ideas will be found upon this subject, and it may also be said that results vary to a con-

FIG. 30.—Face and side view of scion for nursery graft. These are somewhat larger than the most desirable size.

siderable extent from year to year, even though the grafting is done at apparently the same stage of development. The best average results, however, have been obtained by commencing the work just in time to complete it as the seedlings are coming into leaf.

In grafting by the method which we shall describe, the first operation

consists in hoeing away the dirt from about the seedlings in such a manner as to expose the trunk down to the crown of the root. Several inches of surface soil must be soft, moist and mellow at this time, and if not already in this condition, they must be made so by irrigation, cultivation, or whatever method is necessary. The young trees are then cut off with pruning shears or a saw close above ground. With a sharp grafting knife the operator then cuts a sloping bevel on one side of the stub and then with his knife splits the stub down on this side for about an inch, as shown in Fig. 31—1.

The Scion.—Scions of the desired variety should be chosen and cut from the tree at some time during the winter after growth has ceased and the tree become dormant, choosing scions from the most productive and best trees and branches. Most propagators prefer to cut their scions some little time ahead of the time of grafting, as they consider a sort of curing process beneficial. The best wood for scions consists commonly of that of the previous season's growth, bearing well-formed buds fairly close together, and with as much as possible of solid wood rather than pith. Occasionally two-year-old wood may be used for scions, but such wood commonly is deficient in good buds. Some consider only terminal buds desirable for scions and use therefore simply the tips of the shoots, but lateral buds develop equally well and their use enables the propagator to utilize his wood to a much greater extent. Grafting wood is commonly cut up into sticks about one foot in length, each of which bears from 4 to 6 buds if the wood is of the most desirable form. During the period between cutting the scions and the time of grafting, the wood must be stored in such a manner that it will retain its moisture and vitality without at the same time getting too wet and becoming water-logged. There is commonly more danger of the scions becoming too wet than too dry, unless they are carefully handled. With some it is the practice to bury the grafting wood in moist sand, which method is good provided the sand is not kept too wet. In this method the grafting sticks should be buried in sand which is barely moist, and watched carefully to see that they are kept from extreme dryness, without at the same time keeping the sand decidedly wet. There is some objection to this method on the ground that more or less sand clings to the scions and tends to dull the knife and adhere to the surface of the cuts in grafting. Others keep their scions in moist sawdust or sphagnum moss, which does away with the latter objection and keeps the scions in good condition, provided again it is not made too wet. We have found sawdust the most satisfactory material. Others place the scions in a cool, out-of-door shed with only the butt ends stuck into moist sand or sawdust, leaving a considerable part of the length exposed to the air. Whatever method is followed the chief

consideration is to keep the wood barely moist without soaking and water-logging it. In the latter case the wood becomes dark colored and if in this condition should be cut off and discarded in grafting. Scions properly kept will remain in good condition for several months, often callousing over on the ends if kept until late in the spring.

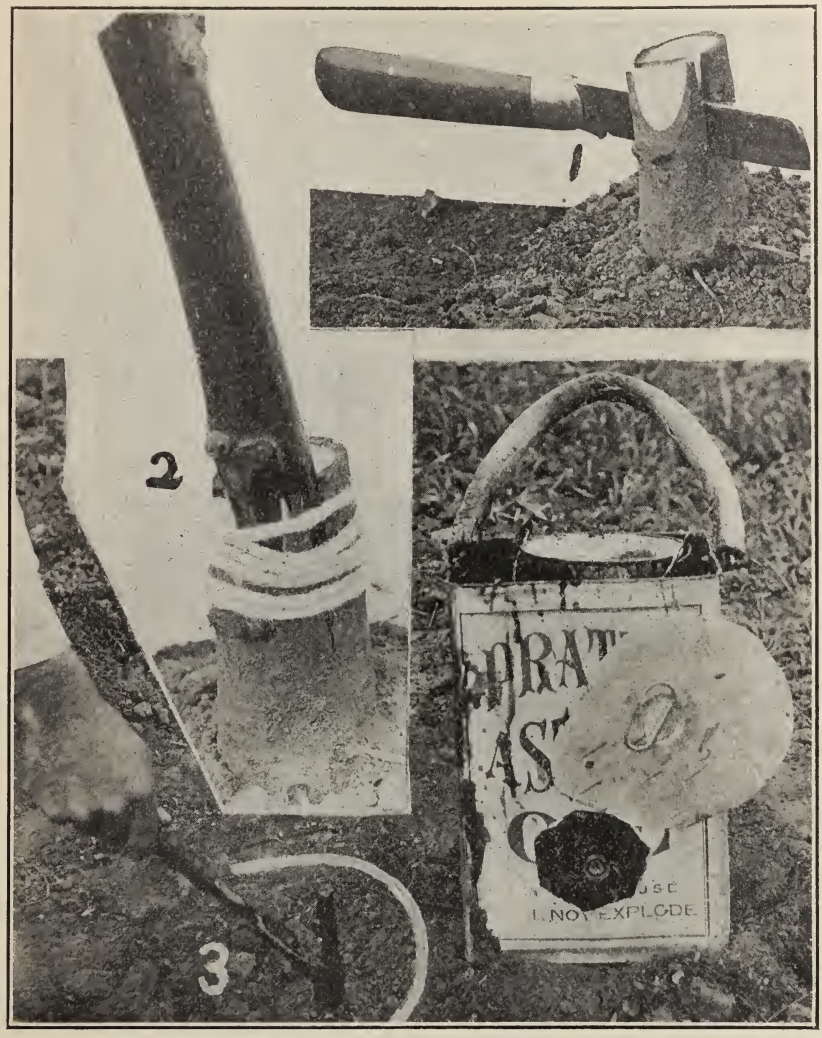


FIG. 31.—1, Splitting the stock for nursery graft; 2, Scion inserted and tied; 3, Waxing; heating stove at the right.

Grafting.—In grafting, the sticks should be cut up into lengths bearing at least two buds each, one near each end. The operator provides himself with a considerable supply of such scions which he carries along in a pocket apron, box, or basket. In grafting he makes a long, clean, sloping cut on one end of the scion, on the side opposite

the bud. The surface of this cut should be smooth and uniform and it is usually made by the experienced operator in one stroke. A split is then made with the knife between the bark and the pith on the longer side of the scion, this split extending nearly down to the bud. It is made nearer the bark than the pith, raising only a thin chip of wood with the bark. For each stock a scion is chosen a little smaller in diameter than the stock, the larger scions being put upon the largest stocks, and *vice versa*. Fairly large stocks are always desirable, especially in propagating new varieties where grafting wood is scarce, as upon them can be used both large and small scions. The stock should not, however, greatly exceed the scion in size, since in such a case complete healing over may not take place the first year. After splitting the scion it is inserted upon the split in the stock as shown in Fig. 31—2. In this operation the object is to make as tight a fit as possible, and to so place the scion that the cambium layer or inner bark will come into contact with that of the stock at as many points and as closely as possible. It will be seen in the illustration that in this method of grafting, the cambium of the stock and scion may be in contact upon at least three different surfaces. The grafter should carry along a whetstone and keep his knife blade clean and razor-sharp at all times.

After placing the scion upon the stock the next operation is that of tying. This consists in wrapping soft cotton twine or raffia fibre tightly about the union of stock and scion in such a way as to hold them firmly together. If raffia is used, it should be soaked in water to make it more pliable.

The next operation is that of waxing, which consists in thoroughly painting over the stock and scion in the vicinity of the union and also the upper end of the scion with grafting wax. It is better to leave a narrow strip on the back of the stock unwaxed in order that the raffia or twine used for tying may decay more readily, or may, if necessary, be cut at this point. With twine it is especially necessary to cut and loosen it after growth from the scion is well started.

Various formulæ for preparing the wax are in use, but all usually consist essentially in a combination of beeswax and resin in various proportions, to which a little oil or paraffine is added, together with other substances in some cases. The following formula is a good one:

Resin	4 pounds.
Beeswax	1 pound.
Linseed oil	1 pint.

The resin and beeswax are melted in a kettle and thoroughly mixed with the oil while in a liquid condition. Some use raw and some boiled oil. The former sometimes foams up to a troublesome extent

in boiling. The formula may be varied by using as much as 10 or as little as 2 pounds of resin to the pound of beeswax, according to the desired consistency of the wax. The greater proportion of resin the harder will be the wax, and *vice versa*. Harder wax is necessary in hot weather, as it should not be soft enough to melt and run. This is less likely to occur in nursery than in top grafting. If too much resin is used, the wax is then hard and brittle. Resin is much cheaper than beeswax, and in nursery work may usually be used in the larger proportions mentioned. One half pound of tallow may be substituted for the pint of oil. In some cases one pound of flour or one to two pounds of powdered charcoal is added to the formula and thoroughly mixed in, with the idea of giving the wax more body and elasticity. Some have substituted paraffine for part of the beeswax in nursery grafting. This is much cheaper. The wax requires heat in order to keep it in a liquid condition, which may be supplied by means of a small fire, or more conveniently, by such an arrangement as that shown in Fig. 31—3. This consists of a coal-oil can with a round hole in the side, over which a disk of tin is fastened in such a manner that it may be raised or lowered for a door. In the bottom of this can is placed a small oil stove on which is set the pot of wax. A handle at the top completes the apparatus, which, while crude, is very satisfactory. Another very good device is that used by plumbers for keeping a pot of solder in a melted condition.

After thorough waxing, in which no cut portion of the stock or scion should be left uncovered, the dirt should be hoed back again about the newly grafted trees, covering scion and bud completely with soil. This must be done very carefully, in order not to displace or knock out the scions, and the dirt should be worked up as fine as possible with the hoe and all hard lumps and rocks removed. This is a consideration to be kept in mind in choosing soil for a walnut nursery, as the success of grafting by this method depends quite largely on thorough covering of the grafts with loose soil.

In grafting by this method on a large scale several men can work in combination to advantage, rather than for one man to do everything. It is of advantage, for instance, for the man who does the actual grafting to do nothing else but this, since otherwise he must be continually getting up and down, going ahead and back, and losing much time. The better arrangement is for one man to hoe the dirt away from the trees before they are cut off, hoe it back again after grafting is completed, and perhaps help in some other way if this does not keep him busy. One man can cut off the seedlings and also do the tying and waxing, first working on ahead of the grafters until he has cut off enough trees to keep them busy for some little time, then coming back and attending to the grafts which they have put in. He should not get

too far behind in the latter operation, avoiding any danger of the grafts drying out before they are tied, waxed and covered.

Many other methods of nursery grafting are in vogue, but as we have said, the one described is as good as any for the beginner, and in our opinion no other method is superior to it. This style of grafting has been developed and very successfully practiced for several years by Mr. George Weinshank, of Whittier, to whom credit should be given in this connection.

FIG. 32.—Grafted trees in nursery, five months after grafting.

After grafting the scions which have taken will soon begin to develop and along with them numerous sprouts from the seedling rootstock. The latter must be continually and very carefully removed before they choke out the growth of the scion or become so large as to leave undesirable scars when they are finally removed. Growth from the scion should be well started, however, before any suckering is done. Suckering is an important operation, since if done carelessly the graft is likely to become displaced even after it has made considerable growth. If

more than one bud on the scion sends up a shoot all but the strongest one should be removed as soon as its growth is assured. The successful grafts will send up shoots very rapidly, and soon these must be tied up to stakes in order to prevent their falling over and becoming crooked or pulling out the scion. If a scion sends up more than one sprout only the best one should be allowed to grow. For tying up stakes at least six feet in length should be used, employing either ordinary lath of this length or 1 by 1 strips, which are very satisfactory. The stakes should be driven in a perfectly upright position as close to the sprout as possible and the latter should then be tied to the stake at least two points in its length with large soft twine or small rope. This tying should be done carefully and not too tightly, as the young sprouts are very tender and increase rapidly in diameter.

Meantime, proper care should be given to the soil by means of the necessary cultivation, hoeing, and irrigation if the latter is practiced. Here, again, there is a common impression that trees grown without irrigation are hardier and more desirable for planting than those to which water is applied during their growth. It is true that a non-irrigated tree becomes dormant earlier in the season and hardens up its terminal growth possibly more completely than does a tree which is kept growing by irrigation as late in the fall as possible. Even though this is true, the fact still remains that the largest trees are everywhere considered most desirable for planting, and the price received by the nurserymen varies in direct proportion to the size of the trees. A tree ten feet high sells commonly for nearly twice as much as one four feet high, and is at the same time more in demand. If properly treated in planting, the larger tree is cut back in any event to perfectly sound, well formed wood, and we know therefore of no disadvantage, either theoretically or in actual experience, in the planting of larger trees which result from irrigation as compared to that of small trees grown without water. In fact, many trees grown where no irrigation is possible have their roots injured, their growth stunted and their trunks sunburned on account of drouth.

If grown with plenty of moisture and on good soil, the majority of the trees should make sufficient growth the first year to bring them up to proper size for selling and planting in orchard form. In the southern part of the State, where the season is long, there is as much trouble from the trees becoming too large as in their being too small at the end of the first season's growth. Trees of ten to twelve feet in height are very common, while the largest specimens run up to fifteen or even eighteen feet during the first season from the graft. There is always a considerable variation in the trees, however, and nurserymen commonly sell walnut trees on the basis of height, making the following grades: 4 to 6 feet, 6 to 8 feet, 8 to 10 feet, and 10 feet and up. A

grafted tree of less than four feet in height at the end of the first season, when grown among trees some of which go up to ten, twelve and more feet, is of doubtful value, as it should presumably have made a better growth if on a good root and with a good union.

From the seedlings where the grafts did not take, numerous suckers usually spring up and it is customary to take off all but one of these, letting the latter grow up into a new seedling top. This will soon grow over the scar where the original top was cut off and may be grafted again the next year if this seems desirable. It is not, however, to be recommended that such trees be grafted again and again the third and even the fourth year, as practiced by some nurserymen in case the grafts do not take. In such cases the root becomes extremely large, and with each year's cutting off of the top the scar at the base becomes greater. It is better to discontinue grafting after the second year and destroy all the remaining seedlings on which the graft has not taken. By far the most desirable grafted tree consists of a two-year-old root and one-year-old top, as described above. Thus the top and root are of nearly uniform size, and, if a good union is formed, complete healing at the point of grafting takes place the first season.

BUDDING.

The operation of budding the walnut is by no means as uniformly successful as in the case of ordinary fruit trees, yet some have performed it with considerable success. Even at best, results in this respect have been somewhat uncertain. Many different methods have been practiced, but these we will not go into in detail, as they are largely a matter of personal skill and there is no reason for supposing one method to be better than the others under all conditions. In general, we may say that most of the walnut budding in this State has been done in the fall, usually in September, the buds remaining dormant over winter and starting into growth the following spring. In some of our own experience, however, we have had good results with spring budding, putting in the buds during May, June and early July and growing from them trees up to as much as ten feet in height during the same season. Spring buds of this height are exceptional, but we have found no difficulty in getting a large percentage of them up to from four to six feet during the same summer when they were budded. Such budding was done mostly on new sprouts coming from one-year-old seedlings upon which grafts had failed, or seedlings which had been too small to graft during the previous winter. For such work the best buds are those upon dormant wood cut during the previous winter at the same time of cutting scions for grafting. Such wood may be easily kept over with the buds dormant until June if properly stored in a cool place with neither too much nor too little moisture. The buds on this grafting

wood do not come off readily when the scions are first cut, but when budding time arrives in the spring the scions, if well kept, will begin to callous at the ends, and the buds will then slip off readily. Wood which is too large, and also that which is too soft and pithy for scions, can be used for buds, and thus it is possible to make considerable more use of a given amount of grafting wood. Buds of the current season may also be used, and for fall work it is necessary to use such buds. We have found that these can be handled most readily, by selecting the best

FIG. 33.—Top-budding; 1, bud completely healed and starting to grow; 2, showing the shoot developed from the bud and tied up to the stub of the limb. The latter is soon cut off just above the bud. The ring of bark attached to the bud would be better if it reached less completely around the limb. Note the constriction at the bud and swelling above it.

developed buds at the base of leaves on the oldest wood of the present season's growth, and cutting off the leaf stalks just beyond the buds about two weeks previous to the desired time of budding. If this be done the leaf stalks drop off cleanly in a few days, leaving the buds ready for use. If the leaves are cut too soon the buds sometimes start into growth while still on the parent shoot. Good buds may sometimes be obtained during the summer and fall on the last wood of the previous year's growth.

The most successful form of bud with us has been a partial ring or flute bud extending only part way round the stem. We have had the best success with buds having a portion of bark attached about one half to three quarters of an inch wide and three quarters of an inch long. The former dimension is that measured around the stem and the latter the vertical distance. For cutting and placing such buds a double-bladed knife is most suitable for which we have found a home-made contrivance entirely satisfactory. Two blades are fixed upon a handle in such a manner that they are about three quarters of an inch apart. With this cuts are made on either side of the bud on the bud stick, after which similar cuts are made in the bark of the stock about six inches above ground if the seedling is large enough. These cuts should not extend more than halfway round the tree, leaving the bark intact for halfway round on the other side. Referring to the sentence above, where we state the proper size of the piece of bark attached to the bud, it will be seen that the buds should be put on at a place where one half the circumference of the stock amounts to at least one half to three fourths of an inch. Perpendicular cuts are then made with one of the knife blades at either end of the ring of bark on the stock and this is removed. The bud, previously cut, is then removed, cut off if necessary to the proper horizontal width, so that it will just fit the opening in the bark of the stock. In stripping off the bud the core of wood inside the bud itself usually remains in place without difficulty if the bud is mature enough to be worth using. Usually buds in which the heart wood pulls out are so immature that they would not take in any event. With good buds it is simply necessary to strip off the bark without attempting to include any of the wood. The operator uses his judgment in selecting the seedlings of such a size that the strip of bark bearing the bud, with its one half to three quarters of an inch horizontal width, will be of the right size to extend not more than halfway round the stock. Where the bud reaches nearly or quite around the stock, forming a more or less complete ring bud, a bad constriction and swelling is often produced at this point, making an undesirable sort of tree. The bud may be put in just above ground, or at any other point where the stock has the proper size, as well as at six inches from the ground, as above stated. The object of the latter is to leave space for further attempts below the first bud in case it does not take. The bud is slipped into place and tied either with waxed cloth, such as is used in budding citrus seedlings, or with soft cotton budding twine. We have had the most uniform success with waxed cloth. The tying should be done very carefully, bringing the inner surface of the bud bark into smooth, close contact with the exposed wood of the stock, especially close about the bud itself. After securing the buds in place they should be watched carefully and if successful they will remain green and soon unite with the stock. Spring buds may

usually be unwrapped within from one to two weeks, the latter period being usually about right early in the season. In later budding the wrapping must stay on longer, usually at least three weeks in July, while with fall buds which are to remain dormant over winter six or seven weeks will do no harm. With spring or summer buds which are to be forced into growth the same season about one third to one half of the seedling top should be cut off after the buds are unwrapped. After the bud has started into growth and its further development is assured, the stock should be still further cut back as closely as possible to the bud without injuring it and the end waxed over. In the case of fall buds which are to remain dormant over winter the seedling top should not be cut off at all until spring, when it may be cut off entirely at one time if the growth of the bud commences vigorously early in the season, or if the bud does not start promptly it may be safer to cut off only one half of the top and the remainder after the bud commences to grow.

This form of bud is shown on a top-worked tree in Fig. 33. The buds in the figure, however, extend further around the stem than we now think desirable. A bud which does not reach more than halfway round does not produce the swelling and constriction of the stock seen in these pictures.

Other methods than the above have been tried for budding walnuts and some have given more or less success both with us and others. The ordinary shield bud has been entirely unsuccessful in our experience, and it seems to a certain extent that the larger the portion of bark taken off with the bud the better are its chances to stick. Some who have used an inverted shield or T bud, pushing the bud up rather than down and slipping it under the bark, have had better success than by the ordinary method of making this bud. Complete ring or annular buds take as readily as the flute bud described above, but there is objection to this form on account of the constriction produced in the stock at the point of budding. Where a strip of bark is left on the back side of the stock, as in the flute bud which we have described, this objection is obviated.

E. J. Kraus, in Circular Bulletin No. 16 of the Oregon Agricultural Experiment Station, recommends what he calls a hinge bud, which is a large, rectangular patch bud inserted under the bark of the stock. In this form of budding two transverse cuts are made in the bark, one above the other, about half an inch long and three quarters of an inch apart. The two are connected in the center with a longitudinal incision and the bud, after being cut with a portion of attached bark of the proper size and shape, is slipped down under the bark of the stock in the same way as in the ordinary shield or T bud.

The uncertain results which almost always accompany walnut budding, even at the best, appear to come about largely on account of the

tendency of the freshly exposed tissue of the walnut to oxidize and turn black. After this has once happened the tissue is sure to die and no union takes place. A further uncertainty is connected with the growth of the bud even after it has apparently formed a perfect union. Quite frequently a good union seems to have taken place, the bark of the bud remaining fresh and green, but after this the bud dies and therefore no sprout is able to develop. In all walnut budding particular skill and dexterity is necessary in order that the fresh surfaces or cambium of the bud and stock may be exposed as little as possible to the air during the operation. The operator must work rapidly and at the same time carefully, making a close fit in each case, tying each bud so that the inner surface of the bark will come into close contact all over the exposed surface of the cut in the stock, and getting the buds cut and into place just as quickly as possible without unnecessary exposure to the air. The buds should not be taken off until the last possible moment so that only one bud can be cut at a time. In working with a single-bladed knife, it is usually necessary to cut the bud first and then lay it on the stock in order to make the cut on the latter of the same size. By using a double-bladed knife this becomes unnecessary, and the bark can be removed from the stock before the bud is entirely removed. In case of any little delay after cutting the bud it is a good idea for the operator to put the bud in his mouth until he is ready to place it upon the stock, rather than to keep it exposed to the air. In nursery budding on a large scale it may be found economical for the men to work in pairs rather than for each man to do all the work. One man, for instance, may make the cut on the stock, cut and place the bud, while the other ties, waxes or otherwise assists to the best advantage. There should not be the slightest delay, however, at any stage of the operation.

As a general proposition, there are but few advantages in nursery budding over grafting for one who is particularly skilful in the latter operation. Grafting can be done more rapidly, and is certain to produce good-sized trees the same year if they are well cared for. Budding, however, may be valuable at times, especially if practiced in conjunction with grafting. In the case of propagating varieties where grafting wood is scarce, the available supply goes considerably further in budding than in grafting, since only one bud is used for each tree and buds can be taken from soft, pithy wood, or large wood which would not make a scion. Another useful feature of budding is that it may be practiced in spring and early summer upon trees which were too small for grafting, or upon the sprouts coming from trees on which grafts did not take. It also extends for several weeks the rather limited season during which grafting may be done. Another advantage

of budding lies in the fact that very little suckering has to be done, such as is necessary after grafting, and this is a valuable consideration. Again, the budded tree, having the union well above ground, is not as liable to decay or heal poorly at this point as is the graft. Both operations may often be practiced to advantage by the nurseryman, grafting in February and March all the stocks which are large enough, budding in April and May those which were too small for grafting, and in June and in early July the sprouts which have come up from the unsuccessfully grafted trees. By budding several inches from the ground those seedlings which do not take can be budded again a little lower down, and thus by diligent and continuous work it is not impossible to obtain a nearly perfect stand of salable trees during the first year. Fall budding upon stocks in their second year of growth produces very large trees the following year, and so is of some advantage. With very thrifty seedlings it is possible to do a good deal of budding during the late summer and fall of the same year in which the nuts were planted, and this again may sometimes be of advantage in obtaining a long season during which the stock may be worked. Inquiry is sometimes made as to the possibility of producing salable trees in one year by sprouting nuts early, forcing their growth in the nursery so that they may be budded in June or early July of the same year, and then pushing the sprout along to make a tree that same season. While this is possible with peach and other fruit trees, it is not likely that it can be accomplished with walnuts to any extent or that the green, immature buds thus produced would have any ultimate advantage in orchard planting. The future care of buds is the same as that of grafts and need not be particularly described.

METHODS OF TOP-WORKING.

In working over good-sized walnut trees, either in the case of black walnuts planted in orchard form, black walnuts standing along roadsides, in dooryards, or any other place where it is desired to work them over into English walnuts, or in the case of English walnuts which the owner wishes to change over into other varieties, somewhat different methods are usually employed than those used in nursery work.

Top-Grafting.—In regard to the time of grafting, choice and care of the scions, making of grafting wax, and other operations common to both processes, the same general rules apply. Trees to be worked over may be cut off either in the main stem from two to five feet above ground, if this is at least 3 to 4 inches in diameter, or the limbs may be cut off and grafted either just above the main forks of the tree or further out, according to the size of the limbs and the amount of grafting wood available. It is not usually advisable to cut off extremely

large limbs, exposing a large surface of wood to decay and also making the growth of the scions somewhat less certain than if they are inserted in smaller limbs. Usually cuts of 3 or 4 inches in diameter are the most desirable size, although larger and also smaller cuts can be grafted with more or less success. In grafting over orchard-planted black walnut trees it is not usually advisable to graft them before they have a diameter of at least 3 inches at the point of grafting, and 4 inches is

Fig. 34.—Views of four different sides of scion for top-grafting by side cleft method.

even better. If the trees are grafted while quite small, the tops are likely to greatly outgrow the trunk and form a topheavy, undesirable form of tree. In working over trees in the top less time and fewer scions are required if the limbs are cut well back toward the main forks, making fewer stubs to work upon, than if the limbs are cut off further out where the branches are more numerous. In the latter case, however, the chances of success are somewhat better than when the work

is done on very large stubs. Usually cuts of less than 2 or more than 4 inches diameter are undesirable.

A method used in some cases is that of cutting off the tops quite

Fig. 35.—Top-grafting. Bottom—Making the cleft. Top—Scions inserted and waxed.

severely one year and then allowing the stubs to sprout, which they usually do very vigorously, and grafting on the best of these young sprouts the following year. In following this method some have cut

off trees a foot or more in diameter directly through the main trunk and then worked the following year on the sprouts coming from this. Such a method is of doubtful expediency on account of the great liability to decay of so large a cut surface.

The time chosen for cutting off the top or limbs for top-grafting is usually that when the grafting is done, namely, just before the trees commence to send out new growth in the spring. One of the most important considerations in this respect is that of the bleeding of the trees when cut off, which sometimes takes place quite profusely. No general statement can be made as to the time or conditions under which such bleeding takes place, or does not take place, since its occurrence is quite irregular. In some soils, especially light sandy ones, and in some seasons it seems almost impossible to find a time when the trees can be cut off without bleeding. We have seen practiced a method of cutting off the tops and branches early in the winter, in December for instance, when there is practically no danger of bleeding, and then at the time of grafting making a fresh cut just back into normally green tissue. In this way some who have had trouble with bleeding have thought that much benefit was obtained. Another method consists in cutting off the tops just before grafting and then, if bleeding takes place, boring several half-inch holes in the butt of the tree near the ground in order to allow the surplus sap to escape at that point. Usually the tops may be cut off at the proper time for grafting without any serious trouble from bleeding except now and then in certain individual trees, or sometimes in certain individual orchards on an especially warm soil. The cuts should be made carefully in order not to split and tear down the stubs. The best method consists in first making a cut on the under side in the case of a horizontal limb, or cutting partially through on one side in the case of a tree cut off in the trunk, then cutting completely through on the other side an inch or two above the first cut. After taking off the limb or top a fresh cut is made clear across, just below the first cuts, in sound wood.

The question sometimes arises, especially in working over good-sized or large trees, whether to cut off all the limbs at one time or to work over only part of the top the first year, leaving part of the original branches over until the second or even later years, thus extending the grafting over two or more years. Most experience has been against the latter method and in favor of cutting off and grafting the whole top at one time, even with the largest trees. Ordinarily, if part of the original top is left, very little growth results from the scions, the whole vigor of the tree seeming to go into the remaining portion of the original top. We have heard the plan proposed of grafting the north side of the tree first, then the east, south and west in successive years, this idea being based on the well-established observation that grafting is

decidedly more successful on the north than on the south side of the tree. We do not know that this method has been tried sufficiently to enable final judgment to be passed upon it, but certainly with trees of

FIG. 36.—Top-grafting; scion inserted.

not extremely large size and especially in grafting over orchard-planted black walnut trees, it is more practical to cut off the whole top, either in the trunk or main forks, and graft it all at once.

The method used in top-grafting is usually the ordinary cleft graft

or a modification of the same. Some operators simply split the stock through the middle, insert the wedge in the cleft, trim the split edges of the bark and cambium smoothly with a sharp knife, cut the scion to a smooth bevel on either side, and insert the same carefully, taking special pains to make a good fit and bring the cambium layers of the stock and scions into intimate contact. After removing the wedge some grafters fill the cavity across the heart of the stub with paper or some other material before waxing. Another, and in our opinion somewhat better method of cleft-grafting, especially on stubs more than two inches in diameter, is that shown in Fig. 35. This differs from the ordinary method in that instead of making one cleft across the middle of the stub two or more are made at uniform distances apart out near the edge, splitting off slabs about one half an inch in thickness. A special tool is useful both for this or for ordinary cleft-grafting, as shown in Fig. 35. In making the splits the splitting wedge is held in a horizontal position over the place where the cleft is desired and driven in to a depth of about one half inch. It is then tilted up in a slanting position and driven down to a depth of one and a half to two inches, first at one end of the cut and then at the other. The limb in Fig. 35 was $3\frac{1}{4}$ inches in diameter. In this two clefts were made, each $\frac{1}{2}$ inch thick by $2\frac{1}{4}$ inches long and 2 inches deep. The rough edges of the bark were smoothed with a sharp knife and the cleft held open with the terminal portion of the tool, as shown in Fig. 36. The proper scion for such grafting is shown in Fig. 34. This is prepared by beveling off one end into a wedge shape, cutting entirely through the pith on one side, and then down to the pith on the other. The back side of the wedge, that which is placed toward the outside of the tree, is made wider than the side which goes toward the interior of the tree. There should be two buds on each scion, one near each end as shown in the illustration. Two scions are carefully fitted into each cleft, taking great pains to make a good fit and bring the cambium portions of stock and scion into intimate contact. If the bark splits irregularly it should be smoothed with a sharp knife. In all cleft grafting it is well to slant the point of the scion a little toward the center of the stock so that the upper end of the scion points out a little in order to be certain that the cambium may cross at least at one point. In grafting limbs up to 4 inches in diameter two clefts or four scions are commonly put in by this method. In larger limbs more clefts and scions may be used. It is desirable to put in as many scions as possible without at the same time splitting off slabs of too little thickness, since the more scions that grow the quicker will the cut surface heal over. It is much better to get several scions started, even though it be necessary to cut off all but one the following year rather than having only

one scion from the first with a large surface exposed to decay. After inserting the scions and removing the wedge the scions may be tied in with soft budding twine, wrapped several times around the whole stub,

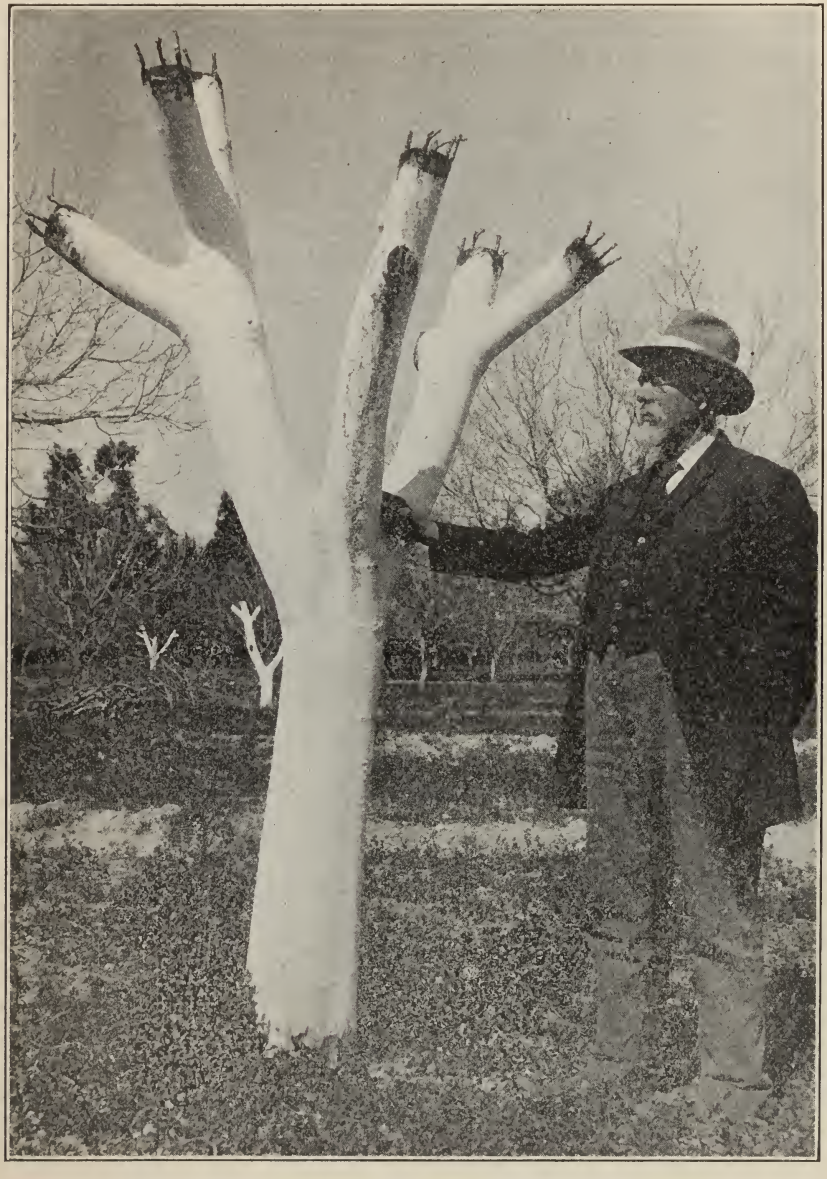


FIG. 37.—Large, top-grafted tree. J. B. Neff's orchard.

but this is not ordinarily very necessary. Only in cases where the work is being done with extreme care is tying often resorted to.

One of the most important operations of the whole process is that of

waxing. Grafting wax should be prepared as described on page 221, and every part of the exposed surface should be very carefully painted over with a solid coating of wax. Great pains should be taken to see that no spots are left, however small, either on the cut end of the limb or the clefts containing the scions, which are not completely covered with wax. If any opening is left through which the air may penetrate, drying and oxidizing the fresh surfaces of the scion or stock, the grafts will almost

Fig. 38.—Top-grafting; scions starting into growth.

certainly perish. Much care should be taken while waxing not to knock out or disturb the scions in the least. One waxing is not sufficient, but after a few days the grafts should be gone over again, closing carefully any places found to be unwaxed. A little later, when the grafts begin to grow and swell more or less, it will be found that the wax is very likely to split or peel off and so they should be watched very carefully until thoroughly united and kept liberally covered with wax. The pro-

portion of resin and beeswax contained in the material may require variation after the first waxing. Too much beeswax makes a soft wax which melts easily in the sun, running away from its proper position, while if too much resin is used the resulting wax is stiff and brittle and readily cracks. Beeswax is much more expensive than resin, and it is therefore desirable for economy's sake to limit its use.

It is the practice of some grafters to enclose each stub, after grafting, with a large paper sack, hood or cuff, in order to protect the tender young sprouts from sun, wind or frost. As the sprouts elongate the paper is pulled open at the top to let them through. If the scions are tied in with string this must be cut as soon as they are well started in order that it may not cut into the growing scion.

Top-grafting at best is not always successful, even with the most experienced operators. Much depends on the condition of the tree at the time of grafting in regard to the activity of the sap, and this cannot be foretold or controlled in many instances. At the same time a skillful operator, especially if he has a sufficient choice of grafting wood, can in most cases top-graft the walnut with fairly uniform results. Even after successful grafting has been done, the young sprouts coming from the scions are extremely susceptible to injury from frost and also from hot winds, and failure somtimes results from these sources.

These scions which establish a successful union soon commence to grow after grafting, sending out sprouts from one or both buds which grow very rapidly, having at first a very tender, delicate nature. At the same time, the tree itself sends out numerous suckers which must be suppressed to a large extent in order to give the grafts every opportunity for development. Considerable judgment must be exercised in regard to removing the suckers, especially in cases where some or all of the grafts do not grow. If the grafting is entirely unsuccessful, some of the suckers must be allowed to develop in order to permit the tree to carry on its normal functions. If the grafts grow on some of the limbs but not on all, it may be well to leave a few suckers on the limbs where the grafts did not take. Again, it may sometimes be better to leave at least one sucker on a large limb on which only one graft is growing. The main object should be to give the scions every opportunity for development without allowing suckers to choke them out, while at the same time not depriving the tree too much of an opportunity to produce foliage. After grafting, the trunk and branches of the trees should be painted over with a thick, heavy whitewash as a protection against sunburn. Those stubs in which the grafts do not grow should be kept as carefully waxed as those where successful grafting occurs, inasmuch as the wood is extremely susceptible to decay and must be protected against the same as much as possible.

During the first season it is usually well to allow all the grafts which grow to remain, even though they are too numerous for the ultimate tree, as such growth causes a more rapid healing-over of the cut-off stub and this is very desirable. As soon as the sprouts begin to grow from the scions preparations must be made to support them in some way or they will become topheavy, twisted and broken out by the wind. The most convenient method of doing this consists in nailing six-foot lath directly to the stubs into which the scions were put, and tying the

Fig. 39.—Top-grafting; growth well started and tied up to lath.

sprouts loosely and firmly to these laths. In the case of orchard-planted black walnuts which are grafted directly in the trunk, it is usually necessary to employ a large, tall stake set in the ground, especially during the second year, as the tops on such trees become extremely large and top-heavy. This is one of the objections to this method, as it is sometimes almost impossible to keep the tops up in shape during their early years. At the end of the first season's growth top-grafted trees should be gone over, the laths removed if they seem no longer necessary, the extra

shoots cut out where they are too numerous, the stubs cut off and waxed over very thoroughly where they have died back, and all sprouts from the tree itself either cut off or grafted again if the latter seems necessary. During this second grafting it is usually better to work the

FIG. 40.—Top-grafting; showing growth during the first season.

sprouts rather than the old stubs if the former are available. They may sometimes be budded to advantage. Sometimes when no good sprouts have developed it is necessary to cut the old stubs off again further back and graft into them.

Fig. 41.—Top-grafting; new top produced on a seedling English walnut tree in one season.

Top-Working by Budding.—Trees may sometimes be top-worked to advantage by budding rather than grafting, working on smooth-barked limbs not much over one inch in diameter or on suckers coming from large limbs cut off the previous year. The methods already described as to cutting the tops, treatment of the stubs and methods of budding

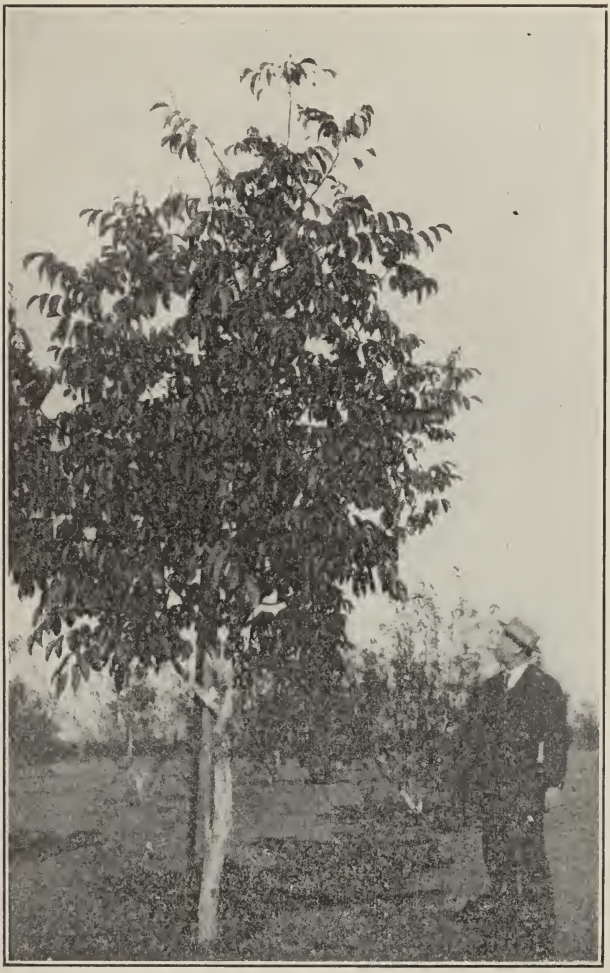


Fig. 42.—Top-grafting; two years' growth on orchard-planted black walnut. Dr. W. W. Fitzgerald.

will apply. Fig. 33 shows the partial ring bud after forming a union and the same with considerable growth developed, the bud-sprout being tied up to the partially cut off limb. The ring of bark on these buds extends a little further around the limb than is desirable.

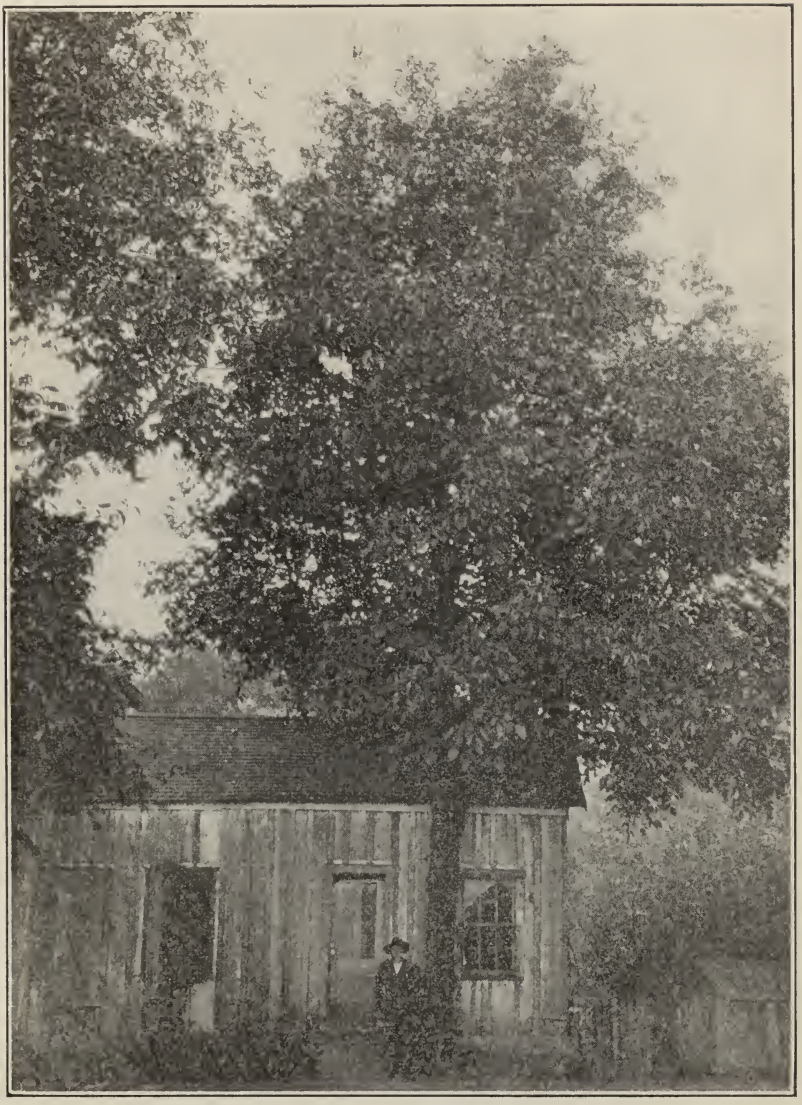


FIG. 43.—Top-grafting; large black walnut tree top-worked. Mr. J. F. Burgess, Superintendent Vrooman ranch.

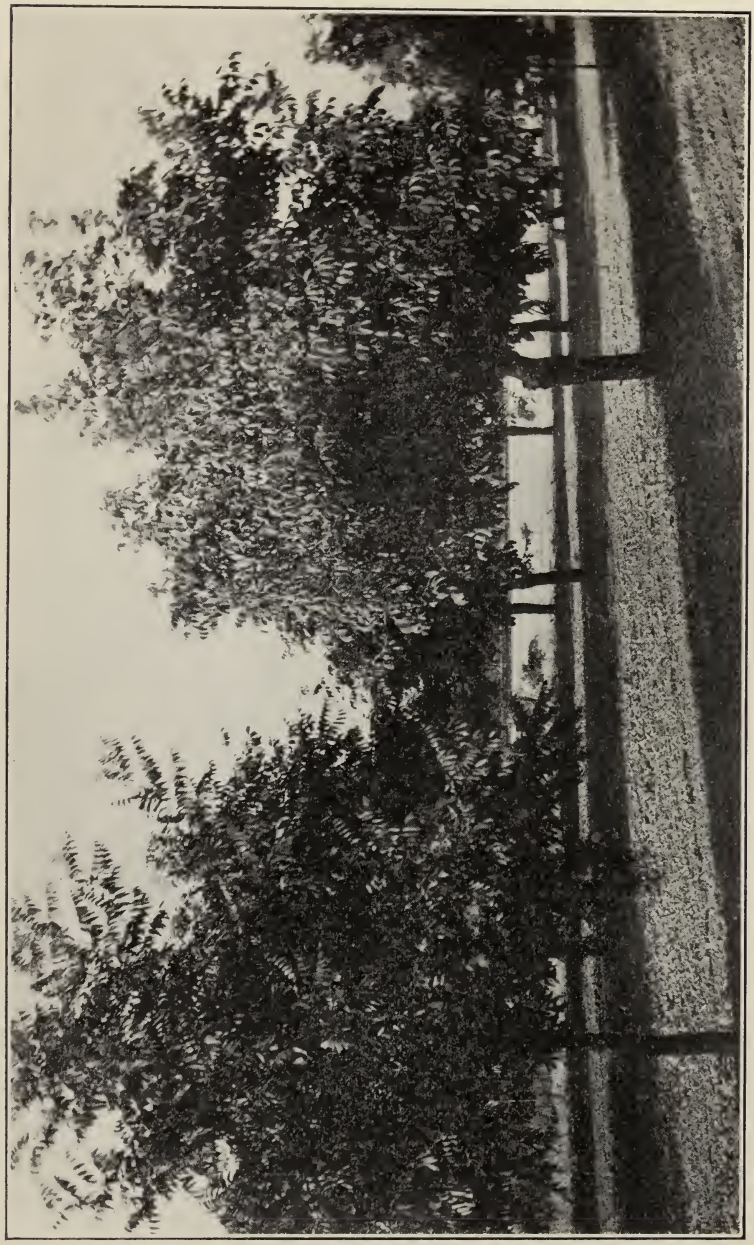


FIG. 44.—Orchard-planted black walnuts; tree at left not yet top-grafted.

DIGGING.

For removing walnut trees from the nursery no better method has been devised than simply digging out each tree individually by hand with long-handled shovels. Plowing the dirt away is of very little assistance and puts the ground into bad shape for walking and standing upon during digging, especially in muddy weather. Usually the best that can be done, especially with good sized trees, is to simply dig out each tree entirely by hand. In doing this opinions differ as to the amount of the taproot which should be preserved, and often the desires of the purchaser must be followed to some extent in this matter, whether or not they agree with the ideas of the nurseryman. One of the most popular fallacies is that concerning the taproot of the walnut tree, many people holding strongly to the view that the root must be kept intact, even to a length of three or four feet, in order to insure proper growth of the tree after planting in the orchard. This idea has been abundantly disproven, and the fact is well established that a root not more than eighteen or twenty inches in length, if well branched, and especially if the top is properly cut back, usually makes a better tree than one much longer. Walnut taproots are very large in diameter in proportion to the size of the top and are composed of very soft, spongy bark and wood. This tissue, if conditions are not such as to start the root into growth promptly, is very susceptible to decay, and a long, unbranched taproot is much more likely to remain in the ground without sending out new growth until it begins to decay than a shorter, well branched root. Fig. 45 represents the most desirable types of walnut roots, 2 being of a more branching type than 1. Roots like these send out new growth quickly and are in all respects the most desirable form. In digging, therefore, care should be exercised not to cut off or bruise the lateral roots within about a foot of the main stalk and the taproot may then be cut off at a depth no greater at most than two feet. Even this is more than is necessary if the root is well branched. Some roots will be found which do not have any taproot even of this length, and in such cases the main laterals should be preserved in good condition. It is well to dig the trees as early as possible in the winter in order to have them ready for sale to the first customers and to avoid the danger of being caught by long-continued rainy weather during which the trees can not be dug. Digging may commence as soon as the leaves have fallen, although unless fairly heavy rains have fallen it may be found necessary to irrigate the ground in order to facilitate the work. After the trees are dug, if they are not wanted for immediate delivery they may be heeled in at some convenient place by digging a trench in which the roots are placed and thoroughly covered with earth. It is sometimes convenient to put each tree back in the same hole from which it was dug,

covering the root again with loose earth, when it can easily be pulled out by hand when wanted. Before delivery or planting the trees should be carefully gone over with shears and pruning saw, cutting off all broken roots and ragged ends back to good tissue, trimming off all

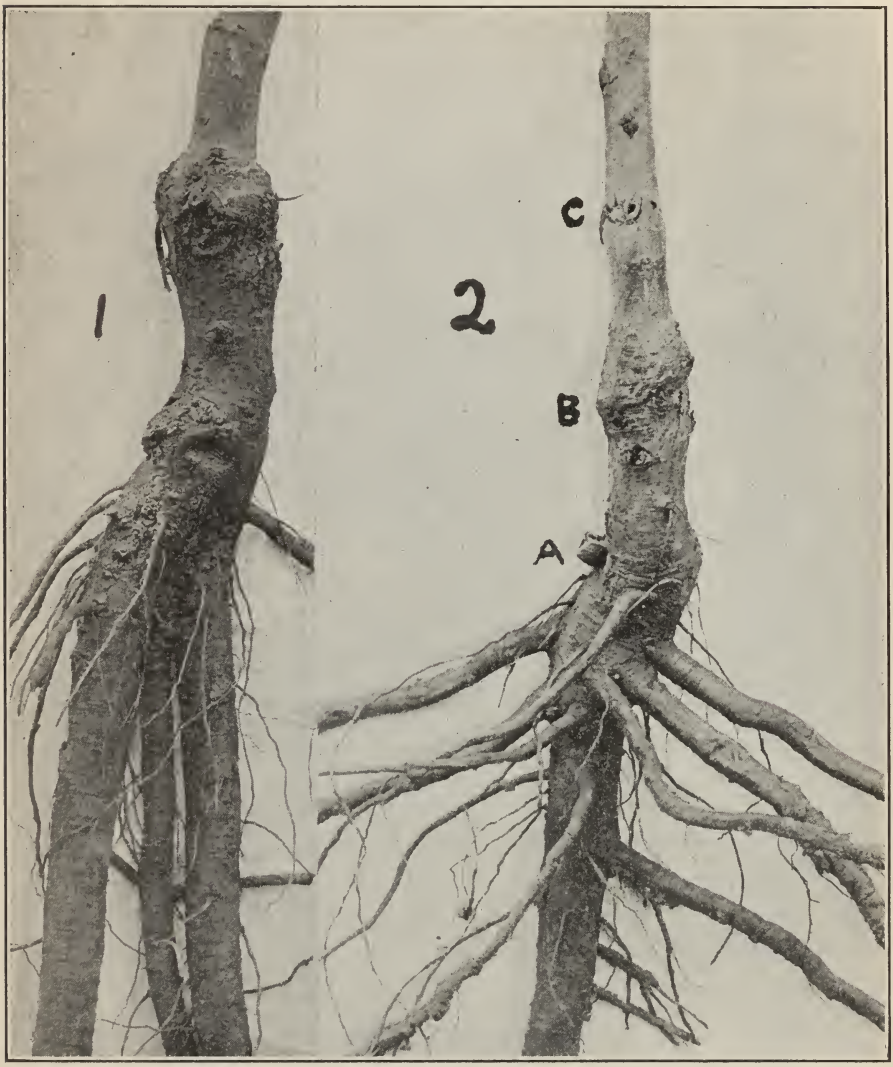


FIG. 45.—1, a good graft union and root; 2, a good graft union and ideal branching root. A, original seedling nut; B, graft union; C, upper end of original scion.

remains of sprouts or stubs of any sort and cleaning them up into a good sound root and a clean stem. All cuts on the crown or stem should be covered with grafting wax. Fig. 46—1 shows a grafted tree which has made a very poor union, leaving a large, dead, decaying stub where the

original seedling top was cut off. It is not necessary that every tree should have this stub completely grown over in the nursery in order to

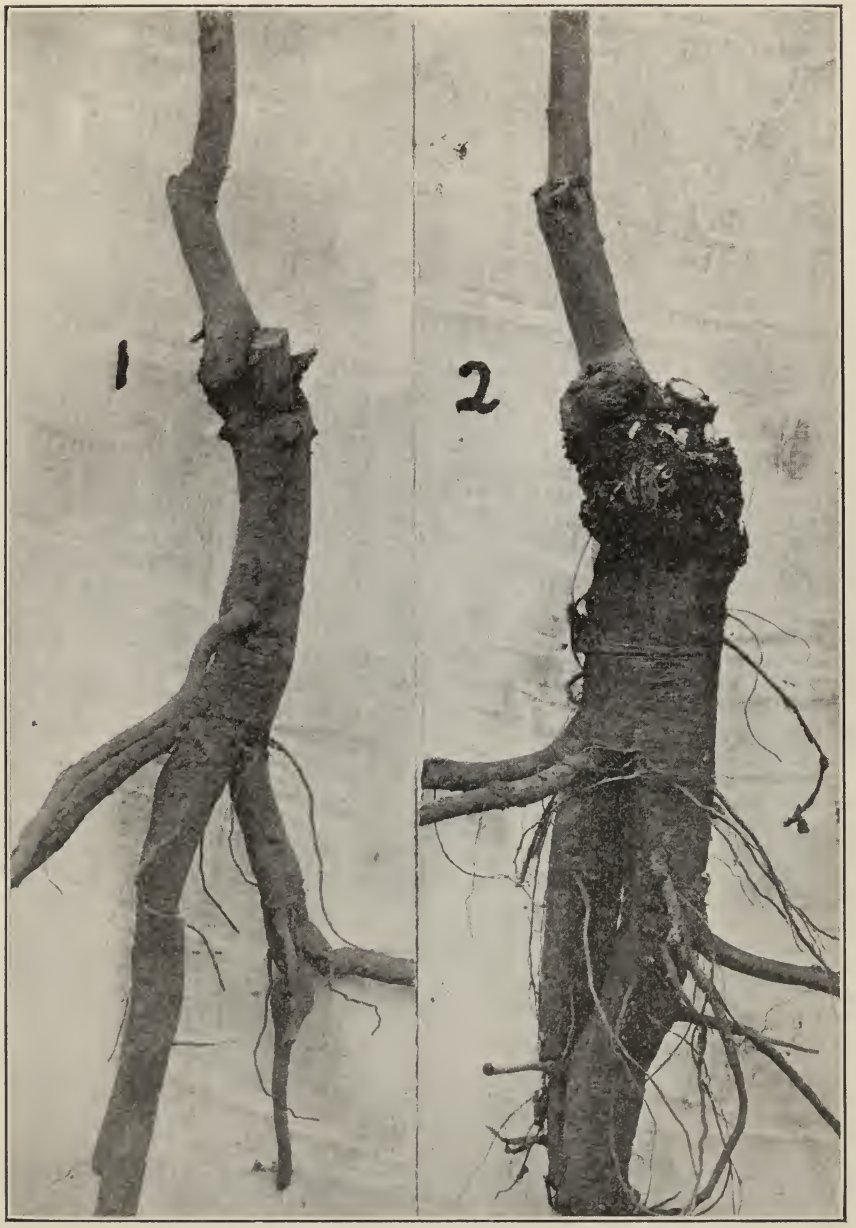


Fig. 46.—1, a poor graft union; 2, a good graft union on a root which has been grafted unsuccessfully once or twice before.

make it worthy of planting, but those with very poor union such as this are of doubtful value and should be discarded if first-class trees are

desired. Fig. 46—2 shows a one-year-old graft on a root which was two years old at the time of grafting, a graft having failed the previous year. In this case the crown of the root is still sound, showing scars of suckers which have completely healed over except when recently cut. This tree is unobjectionable, but such are sometimes seen with very large, old clumsy roots with a poorly healed union and scars at the crown. These are not to be desired. Fig. 45 shows perfect trees, although the rough ends where the roots were cut off have not yet been trimmed. In Fig. 45—2 the original nut from which the seedling grew may be seen at A, the point of grafting at B and the upper end of the scion at C.

After cleaning up the roots and lower part of the stem the next question is that as to cutting back the top. Here, again, radical differences of opinion exist, some growers holding a strong preference for planting the largest sized trees without cutting back the top at all, some preferring a small tree likewise without cutting, while others would cut the top back at various heights. Assuming that the root and top are of the same proportionate size, the same rules as to cutting back must apply either with large or small trees. There is considerable unanimity on one point, namely, that the walnut tree in orchard form should be headed considerably high, at a point about five or six feet from the ground. It is, therefore, possible to obtain this with trees of about this height when planted by not cutting them at all, with trees of greater height than this by cutting them back to such a height, or with smaller trees by planting them either as they are or after cutting back and allowing one shoot to grow up into a trunk, heading this at the desired height. Even when very tall trees are planted without cutting they usually branch naturally at somewhere about this height, and if the tops do not die back the ultimate form of the tree is very much the same with a tall tree whether it is cut or not. The chief objection to planting out trees with uncut tops is that the roots have necessarily been cut off more or less and are, therefore, not able to send up as much moisture to the top as is required. Such being the case, there is danger of the top dying back before a proper connection with the soil is reëstablished by the root, or if it does not die back it may remain nearly dormant for some time, making very little growth and becoming very liable to sunburn. In such cases the tree may stand for one or several years before starting vigorous growth in the top and during this time the trunk may become so badly sunburned that it is seriously crippled for life. The liability of such an occurrence depends largely upon the size of the root, amount of moisture in the soil and the degree to which the root dried out during the time after it was dug from the nursery and before it was planted in the orchard. Trees which are moved only a short distance, especially if the root is dug with extra care, may start

Fig. 47.—A tree planted when about four feet high without cutting back. The space between the hands indicates the following year's growth of the leader, and that above the left-hand the growth of the second year.

into good growth the first season and flourish satisfactorily even without any cutting back of the top. More often, however, the root becomes more or less dried in handling and shipping, the ground in the orchard

FIG. 48.—Three-year-old tree, which was cut back to five and one half feet before planting.

may lack moisture to some extent during the first season and altogether the chances are strong that the tree planted without cutting back will not get a very good start the first year and may receive a serious

setback. In planting an orchard to be grown without irrigation the chances of this are very much greater and the objections to planting without cutting back are increased many fold. If the tops are to be cut at all, one thing is clear; namely, that they should either be cut at the point where the head is to be established; namely, at a height of five or six feet, or if cut lower one sprout must be brought up and formed into a new trunk. Trees cut off five or six feet from the ground are more likely to start well than those not cut at all, but even at this height a long stretch of the old wood remains, which under slightly unfavorable conditions may become sunburned, dried out, or semi-dormant. After this has once happened during the time while the root is establishing a new connection with the soil, the flow of the sap becomes sluggish and impeded and the tree cannot develop with full vigor until new wood is formed.

Observation and experience have led us strongly to the belief that in the long run and in the majority of instances better and more vigorous trees will be obtained by cutting back the top fairly close to the ground and bringing up one strong, new shoot to form a new trunk and top of the tree, rather than by attempting to preserve any considerable portion of the original stem. If such cutting is to be done there is no apparent advantage in leaving more than two feet of the original trunk at the most, since the whole idea is based on the belief that it is better to grow a new trunk than to keep the old one. If such is the object desired, there is manifestly no advantage in cutting off at four or three feet, since in such a case we still have remaining a considerable length of wood subject to the objections mentioned, and at the same time a length which would be attained within a few days by a vigorous new shoot. It is, therefore, our belief that the best results will be obtained by cutting the tops back so that there remain simply enough buds to insure one good sprout to form a new stem. This can be obtained by leaving not over eighteen inches or even twelve inches in most cases. It will sound to many extremely radical and unnecessary with nursery trees, some of which may be twelve or fifteen feet in height and two inches in diameter at the base, to cut off these fine tops ruthlessly to a length of only twelve or eighteen inches. Yet, such a tree with a twelve-inch top and a strong, well-branched eighteen- to twenty-four-inch root will send up a shoot which in almost every instance will produce a top superior to that of trees which were left uncut or cut back to a height, say, of five or six feet. Furthermore, the new trunk will be composed of absolutely fresh, vigorous tissue, highly resistant to sunburn, free from die-back, and of the most desirable type in every way. It is, therefore, our well-considered recommendation that in preparing walnut trees for planting the tops should be cut off to a length

FIG. 49.—Tree cut back to two feet before planting. The whole top above the finger is composed of new growth.

of not over eighteen inches, after which the cut ends should be carefully sealed over with grafting wax. We would do this with trees of all sizes, and would insist particularly upon such a practice with trees going into non-irrigated orchards. After trimming, cutting and waxing, the roots should still be kept moist, either by heeling them in, planting at once in the orchard or proper packing, if they are to be shipped.

PLANTING.

In planting the walnut orchard the ground should be thoroughly prepared as for other fruit trees and staked off for the trees at the desired distance apart, which subject we have discussed elsewhere. A large hole should be dug for each tree, considerably larger than the root, and with the heavy subsoil best suited to the walnut it is extremely advisable that a stick of dynamite be discharged at a still greater depth below the hole. This should then be filled in with top soil, up to proper depth for the tree. The tree is then put in place, planting it fully as deep or a little deeper than it stood in the nursery and the soil should be thoroughly tramped and settled about the roots. If not well planted, a thick soft root like that of the walnut is liable to decay, and special pains should therefore be taken to settle the soil firmly about the roots so that they will immediately begin to absorb moisture and commence new growth. Planting may be done at any time after the trees are ready, usually the earlier in the winter the better, in order to take advantage of the settling and moistening of the ground by the winter rains. After planting, the trees should be carefully watched to see that they are all doing as well as possible and not suffering in any avoidable way. If a considerable portion of the top has been left without cutting back, this should be protected from sunburn by tying about it a rather loose wrapping of cornstalks, tules, or special protectors made for this purpose. It is not well to wrap the trunks tightly in paper or cloth, as this makes the bark more tender after the wrapping is removed. If the tops have been cut black close to the ground one good sprout should be selected to form the new stem, and as soon as the growth of this is assured all the others which start should be cut off. Usually the most vigorous sprout should be chosen, but, other things being approximately equal, it is better to take the one closest to the ground and one on the windward side of the trunk. A good sized, at least a 2 by 2 stake should be set in the ground close to the tree, to which the shoot may be tied up. The shoot should then be tied once or twice to this stake in a similar manner as is done in the nursery until it reaches a height of about six feet, when it should be topped and caused to branch. After this shoot is well established the remaining stub of the old stem should be cut off closely above it and the scar waxed over.

VARIETIES OF THE ENGLISH WALNUT.

The fact has been frequently alluded to in this bulletin that great variation exists in various individual seedling trees of the English walnut, and that as a result of such variation a fairly large number of distinct varieties has been established, each of these having originated from a particular tree which was selected by some one as being particularly desirable on account of certain qualities. Some of these varieties, notably certain French varieties close to two hundred years old, have been kept pure since the original tree was first selected, by budding or grafting. Others, especially the majority of the varieties now most common in California, are of comparatively recent origin and represent the grafted or budded offspring of certain seedling trees in the State which have seemed especially desirable and have therefore been propagated from and in some cases widely advertised and sold on quite an extensive scale. The variations which occur in seedling walnuts consist in a marked difference in the vigor and size of the tree, its rapidity of growth, its general form or aspect, and that of its foliage, the color and texture of the bark, the time of budding out in the spring, the amount of catkins and pollen produced, its productiveness, season of maturity of the crop, and the size, form, color, flavor, and other characteristics of the nut. Also the susceptibility of the tree to various diseases and injurious influences. Seedling walnuts vary very greatly in these respects, although certain general types of a certain degree of similarity among themselves may be recognized. Thus, in California, almost all the so-called Santa Barbara seedlings come out comparatively early in the spring, they are usually thrifty, large trees under favorable conditions, and the nuts are mostly of the soft-shell type as regards cracking quality. The old fashioned hard shells represent another fairly uniform type, even when grown from seed, having rather small, round, very hard-shelled nuts borne upon trees with a certain similarity to one another. The same is true of the so-called paper shells. Trees of all these types bear nuts of about the same color, a dull, neutral or greyish brown. Taking the French varieties we find among most of them the habit of coming out extremely late in the spring, so that a Franquette, Mayette, or Parisienne, and almost all the seedlings derived from nuts of these varieties, leaf out several months later than Chase, Placentia Perfection, or most of the Santa Barbara Soft Shell seedlings, even though planted in the same locality. They also bear nuts almost always of a brighter, more yellowish color than do the California varieties. The meat of the nut is also usually lighter colored.

In other words, we find in walnuts certain types differing very widely in various respects from one another, while among the seedlings from one of these types there is a considerable variation, but not so great

as that between the different types themselves. The various types, individual trees and varieties now to be found in California have almost all descended, as we have shown on page 171, from two sources, namely, the Santa Barbara Soft Shell type, first produced and propagated by Joseph Sexton of Goleta, which came probably from Chile, and second, various French varieties and their derivatives, almost all of which were first introduced or developed by Felix Gillet. It is doubtless true that more than 99 per cent of the walnut trees now growing in this State are descendants of one or the other of these sources. The only noticeable exception to this is the Eureka, which originated as a chance seedling from a tree introduced through another source. It is undoubtedly true that with the exception of the Eureka all the varieties which are worthy of discussion for California planting are either Santa Barbara Soft Shell seedlings, old French varieties, or seedlings of some of these later varieties which have originated in California.

In discussing the various varieties now before the public we should first of all formulate an idea or standard as to what constitutes an ideal walnut. In regard to this, the first and most important quality is undoubtedly that of production. A variety however fancy or otherwise desirable which does not produce comparatively large crops of nuts can not be considered satisfactory, whatever may be its other qualities. As to the ideal or greatest possible production, we may say that while the crop of the present producing seedling groves of southern California averages only about 50 pounds per tree, or 1,000 pounds per acre, there are numerous individual seedling trees in the State which average close to 300 pounds, and a very large number which produce regularly more than 200 pounds. Since thrifty walnut trees, after reaching an age of twelve to fifteen years, should have a distance of at least fifty to sixty feet apart, which means an average of not over fifteen trees per acre, we may estimate that at 200 pounds per tree the crop per acre would equal 3,000 pounds of nuts, which at an average price of 12 cents would amount to $360 gross per acre. This figure, as compared with present returns from the citrus industry, is fairly modest, yet if it could be maintained as a regular income it would represent a very satisfactory return on much of the land in this State which is adaptable to walnut culture. On the highest priced citrus lands of the south, walnuts even on this basis could hardly compete with lemons and oranges. Three-hundred-pound trees would add 50 per cent to the figure estimated and such production should be ultimately attained in an ideal tree having plenty of room at least by the time it reaches fifteen or twenty years of age. As we have said above, however, these results are far above those actually being obtained at present in the walnut industry. At this point we may also consider the relative merits of a fancy variety, pro-

ducing nuts which may sell for at least 25 cents per pound, but producing only 50 to 100 pounds on mature trees, as against a 12 or 15 cent variety which produces 200 or 300 pounds. The comparative desirability of such varieties for planting, so far as they actually exist, can be judged fairly well from our description of the various kinds. The relation between quality of nut and the amount of the product should be very carefully considered in choosing a variety for planting and the grower should not be too much influenced by the appearance of a few sample nuts without regard to the quantity in which they are produced. The ideal tree, of course, is one which would produce large crops of the most desirable type of nuts, but this combination has not been fully attained. Another important point in regard to production is that of the precocity or age of coming into bearing, in which great differences exist in different varieties and between individual seedling trees. Some varieties begin to produce nuts quite abundantly, even in the nursery, and give a commercial crop within three years from planting in the orchard, while others are several years later in coming into bearing. Here, again, this quality must be carefully weighed in choosing a variety, considering its relative value in proportion to other qualities. There is in this connection the possibility of inter-planting, either with more precocious walnuts or some other crop, which may offset the disadvantage of an otherwise desirable variety which is slow in coming into bearing.

The next important consideration is that of the size and weight of the nuts. In almost all varieties and seedling trees the nuts are of good size when the trees are young and first come into bearing, but in many there is a tendency for the nuts to become smaller and smaller as the trees get older and the crops heavier. The size of commercially first grade California walnuts, as we have shown on page 197, is represented by nuts which will not pass through a one inch square opening, while those above 1 3-16 inches command a considerable premium. Nuts of a size considerably greater than this are in demand at still higher prices to some extent, but ordinarily the market for such large nuts is quite limited, owing to the fact that most varieties of this sort are poorly filled with meat. Whether an extra large, well filled nut and one of good flavor, if such exists or could be produced, would be desirable for general planting, is somewhat problematical, although certainly such a nut would command a ready sale and at a good price to a considerable extent. However this may be, it is true that on the basis of present standards the most desirable size is that which is not graded out by a square-mesh screen of 1 3-16 inches, but not so very much larger than this. The weight of the nut is equally important, since this varies widely in nuts of the same size, as may be seen in the table on page 300. It may be seen here that some of the largest

varieties are considerably lighter in weight than others in which the nuts are decidedly smaller. A desirable nut should be well filled with plump meat without too much air space between the shell and the meat. A comparatively heavy shell is more desirable than a very thin, light one, since the nut is better protected, less susceptible to perforation and similar troubles (see page 376), and it is also to be considered that since walnuts are sold by the pound, the heavier the shell the greater is the weight and the more the returns from a given number of nuts. Next to be considered is the shape, smoothness, uniformity and color of the nuts. These qualities may be sometimes of minor importance where walnuts are grown on a very large scale and put upon the market without individuality of any kind, yet for an ideal nut or for one which is to command the highest price, certain qualifications are very desirable in these respects. The most attractive form is usually considered to be a somewhat elongated walnut, rather broader at the base than at the apex. This is not very important, however, since the smoothness, symmetry, and uniformity of the nuts affect their attractive appearance more than their shape. An ideal nut should be quite smooth, free from decided ridges, grooves, or other irregularities of surface; it should be symmetrical rather than one-sided or irregularly shaped, and all the nuts should be of the same general shape and appearance, giving them uniformity and individuality. A variety in which the nuts are decidedly uniform so that the variety is easily distinguished and recognized, even by the ordinary purchaser, has a marked advantage over one in which the nuts are of all sorts of shapes so that only an expert can distinguish the variety from others. The color of the nut is also of considerable importance, although walnuts are almost always bleached before putting them on the market and in this way they are all brought to about the same color. A variety, however, which is of a light, attractive color, is entitled to considerable merit over one which is dull, dark or unattractive.

Next we may consider the cracking quality and sealing of the nut. A thin-shelled- easily-opened nut is somewhat more attractive to the eater than one which is hard and difficult to open, yet from a commercial standpoint this quality is a comparatively unimportant one. A rather firm-shelled nut, and especially one which is strongly sealed at the natural line of opening or suture between the two halves of the shell, is very much to be preferred to one which pops open at the slightest pressure. In the latter case many of the nuts open in drying, or when shaken about in the sacks and bins, moisture and mold spores are admitted, many are spoiled in handling, and such a nut is in every way very undesirable to the grower and of only very slight advantage to the consumer. Concerning walnuts for the table, they are almost

always cracked beforehand in any case, and the necessity of a little pressure more or less is of very slight importance. No variety can be harvested, handled, marketed and kept for any length of time with good, plump, white meats, free from mold and discoloration unless the shell is fairly hard and thoroughly well sealed. Extreme thinness of shell is one of the least important qualifications and is in fact decidedly undesirable. The color of the meat is of considerable importance. As commercially graded in California, nuts with the lightest colored meats are considered most desirable, while those which are decidedly dark, even though plump and of good flavor, are discriminated against. It is, therefore, true that the lighter colored the meat the more desirable is the nut, and a variety in which the nuts run uniformly quite dark-meated is decidedly objectionable. The flavor of the meat varies considerably in different varieties and is of much importance in a high class, fancy trade. In some varieties the nut is sweet and of a pleasant flavor, while the most common undesirable quality in this respect is a bitter flavor. This should be guarded against in choosing an ideal variety.

To sum up, then, the most important qualifications in a walnut variety from a strictly commercial standpoint are that it should be a uniformly large producer of nuts the majority of which will not pass through a 1 3-16 square mesh, and of which very few pass through a smaller opening than a 1 inch size. These nuts should be well sealed, even though somewhat hard shelled, and should be uniformly well filled with meat of light yellowish brown color or not darker than light brown or amber. For a more fancy trade the nuts should be of attractive, uniform shape and color, smooth surface, and particularly high quality and agreeably flavored meat. A variety which would combine all these characteristics to a very high degree, including both those of production and quality, would form the basis of a crop which even the citrus industry could scarcely equal in attractiveness and profit.

COMMERCIAL VARIETIES.

The following seven varieties will be most fully described, being those of which nursery trees are most commonly available and those which we have been able to see growing and obtain nuts from for a period of several years. Some of the varieties in our second, miscellaneous list may be better than any of these, but, if so, their merits have not yet been fully established.

CHASE.

Origin.

This variety originated in a tree standing about three miles south of Whittier upon a ranch formerly called the Chase place, which has changed hands several times during the last few years. The tree is said

to have been planted in 1886 among a lot of seedlings obtained from Felix Gillet. One story has it that the tree is a seedling of the Mesange variety, although we are unable to trace the origin of this idea. The nut certainly has no resemblance to that of the variety mentioned but seems to be of the Santa Barbara Soft Shell type. The variety owes its prominence to Mr. A. R. Rideout, of Whittier, who has propagated, sold and advertised it widely during the past few years. It has not yet been tested to any extent in the north, although quite extensive planting of the variety has recently been made in that part of the State.

NUT.

Size.

Medium to large on young trees, small on original tree. On young trees average $1\frac{1}{4}$ by $1\frac{3}{8}$ by $1\frac{5}{8}$ inches, with many larger. Nuts on old tree much smaller, with many less than 1 inch long.

Form.

Broadly oval or rounded, symmetrical, flattened, apex and base of equal breadth. Apex terminating in a short and pronounced point or beak.

Surface.

Quite smooth and even.

Color.

Neutral light brown, without the pinkish cast of Placentia Perfection.

Uniformity.

Strong, in trees of real Chase origin. In some cases the variety has become mixed with other kinds, which probably accounts for some apparent deviations from the type.

Cracking Quality.

Nuts poorly sealed, both at apex and base, so that they are very easily opened with the fingers.

Pellicle.

Light tan to light brown.

Meat.

Uniformly plump and well filled. Averaging nearly 50 per cent of total weight of meat, at the same time having a heavy shell.

Flavor.

Not pronounced. Mild and free from any decided characteristic.

TREE.

Foliation Period.

Very early. About the earliest of any named variety. Earlier in southern California than the average of the seedlings.

Growth.

Very vigorous and thrifty. Young trees have a characteristic, upright, rather stiff appearance, the branches being straight and all coming from the uprights at the same angle. This appearance is lost after fruit spurs become abundant.

Foliage.

Abundant and thrifty.

Harvest Season.

Early.

Precocity.

Quite strong in the south. One of the best in this respect.

Production in Older Trees.

The original tree is said to have produced 325 pounds in one year and is uniformly a large producer. This is due to its great size as well as fruitfulness, as there are few larger walnut trees in the State than this. Our own five years' observation of this tree has shown it to be unusually thrifty and vigorous and a bearer of heavy crops, even under adverse conditions. Its long sustained vigor of growth is in fact the most valuable characteristic of the variety.

Susceptibility to Blight and Other Troubles.

The original tree shows considerably less blight than its neighbors, although not immune to the disease. It is so large, vigorous and thrifty that good crops are produced in spite of the disease. The same vigor of growth, together with the abundance of foliage protects the nuts to a large extent from sunburn and other climatic injuries. The nuts of the original tree have been decidedly free from sunburn as compared with those of neighboring trees.

Some young groves of this variety have shown considerable perforation in the nuts, but the old tree is noticeably free from this trouble. See page 376.

GENERAL REMARKS.

From the above description we may sum up the characteristics of the Chase variety by saying that it is a very large, thrifty, vigorous-growing tree, which on account of its vigor of growth is a good producer and comparatively free from disastrous losses by blight or other injurious influences. Its nuts have no exceptional characteristics, but are of good average quality as compared with the product of the present groves of southern California. The tree has considerable precocity in bearing and may therefore be recommended to those who desire quick results, both in growth of tree and production of nuts.

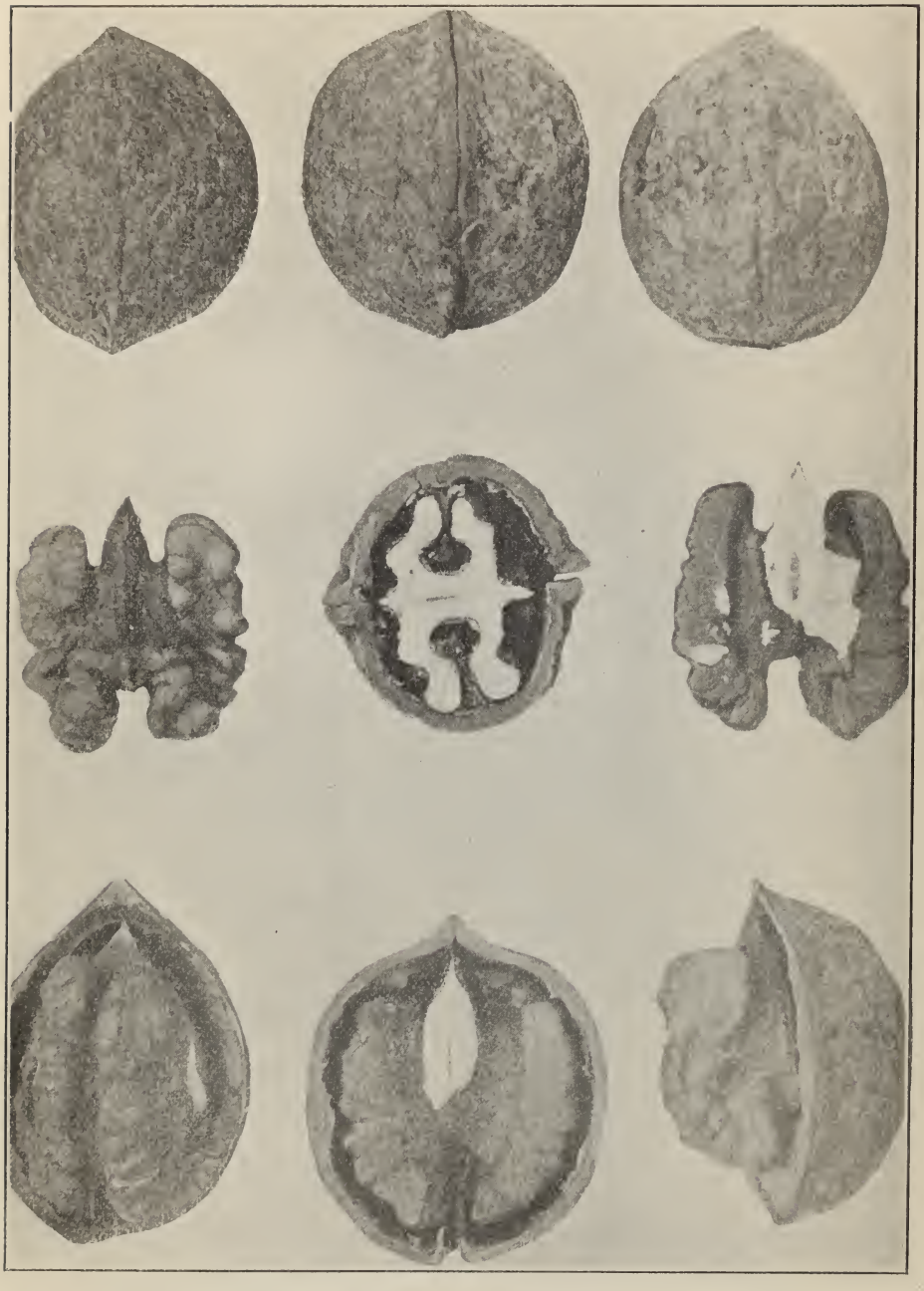


Fig. 50.—Chase walnut, natural size.

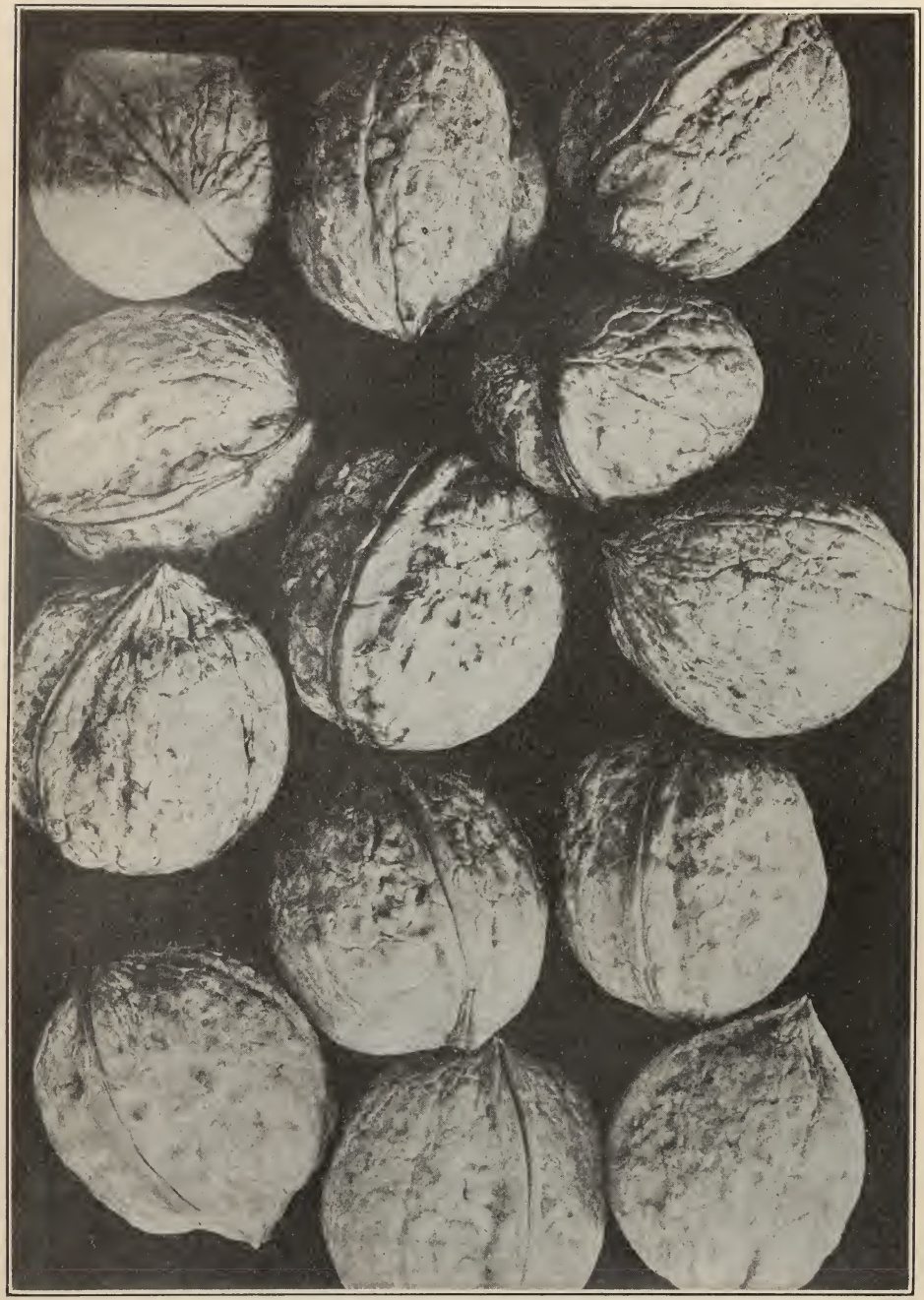


FIG. 51.—Chase walnut, natural size.

CONCORD.

Origin.

This variety originated in a seedling tree on the place of Mr. George M. Westcott, of Concord, Contra Costa County. The original tree came from the late Felix Gillet and is said to have been a seedling of the Cluster variety. It was planted about 1893. The variety obtained considerable fame in its own immediate neighborhood and was propagated there quite extensively by top-grafting upon native black walnuts some

Fig. 52.—Chase walnut, original tree.

time before it was exploited in a popular way. Mr. Ely Hutchinson of Concord propagated the variety quite largely on his place, thus giving it a thorough test in that locality. It was taken up by Mr. Leonard Coates, the nurseryman, about 1908 and propagated, advertised and sold quite extensively by him thereafter. Not yet much tested in the south. One of the first descriptions of the Concord is

found in an article by Mr. Coates in the *California Cultivator* of October 7, 1909, page 339.

NUT.

Size.

Medium.

Form.

Broad and short, with a square cut base slightly wider than the apex in most specimens. Apex very broadly pointed. Some of the nuts slightly elongated and somewhat unsymmetrical at both ends.

Surface.

Medium smooth, with a considerable percentage of rather rough specimens.

Color.

Tan. Lighter than most of the southern California varieties, but a little duller than San José, Franquette, and the best Mayettes.

Uniformity.

Fair. A considerable proportion of the nuts rougher and more pointed than the type. There is also a considerable variation in color.

Cracking Quality.

Nuts fairly well sealed, but cracking in the fingers without much difficulty.

Pellicle.

Very light and attractive.

Meat.

Plump and well formed, filling the shell very completely.

Flavor.

Mild and free from any decided characteristic.

TREE.

Foliation Period.

Medium late. Decidedly later than Placentia Perfection, but considerably earlier than Franquette. According to Mr. Hutchinson, it is about a week later than the Placentia and three weeks earlier than the Franquette in his locality. In the south there is considerably more difference than this between the Placentia and Franquette, and the Concord is apparently nearly intermediate between them. Its foliation period is very nearly the same as that of Eureka. The foliage is held well into the fall.

Growth.

Vigorous and rapid in the case of young grafts. The original tree is decidedly small for its age and the apparently favorable conditions under which it stands, but young trees or grafts observed in various parts of the State appear to be particularly thrifty in growth.

Foliage.

Abundant and vigorous, persisting in good condition late in the fall.

Harvest Season.

Medium or fairly early.

Precocity.

Apparently fairly good. Considerably more precocious than Franquette and perhaps less so than Placentia Perfection, Chase and Prolific.

Production in Older Trees.

The possibilities of this variety as to permanent production cannot be accurately judged. The original tree is rather small, and its production could certainly be much exceeded by well grown, grafted trees. Mr. Hutchinson's trees consist of top grafts on large black walnuts, growing without irrigation. The variety is probably a better bearer than Franquette, but less productive than some of the southern varieties. More than this cannot be said at present. The possibilities of this, like all other varieties, will probably vary to a considerable extent in various parts of the State.

Susceptibility to Blight and Other Troubles.

The Concord has been advertised as being especially desirable on account of immunity to blight. On account, however, of the very slight extent to which it has been tested in this respect, we do not feel that any statement upon this matter is justified. There appears to be considerable doubt as to the extent to which true walnut blight exists in the original locality of the Concord, and in any event it is certainly one where conditions are not favorable to the occurrence of this disease. Being late in coming out in the spring, it is probable that the Concord will prove considerably free from blight as compared with earlier varieties. In respect to sunburn, this variety appears to be well adapted to a hot, sunny region, inasmuch as conditions of this sort exist to a considerable extent in its original location and the nuts produced there are of very light meat, with no serious discoloration from the sun. The foliage, moreover, is abundant and thrifty, affording shade to the nuts.

GENERAL REMARKS.

The Concord is perhaps next to the Franquette the best tested variety for the north and central interior portions of California. In Contra Costa County it is to be found to the extent of several hundreds of trees of various ages, and has proven itself there to be of thrifty, vigorous growth, fair quality, and a regular producer of satisfactory crops. It is late enough in coming out to protect it to a considerable extent from frost and blight, yet not extremely late in maturing its crop in the fall. Young trees make a quick, vigorous development and appear to be fairly precocious in bearing. The nut is of fairly good appearance

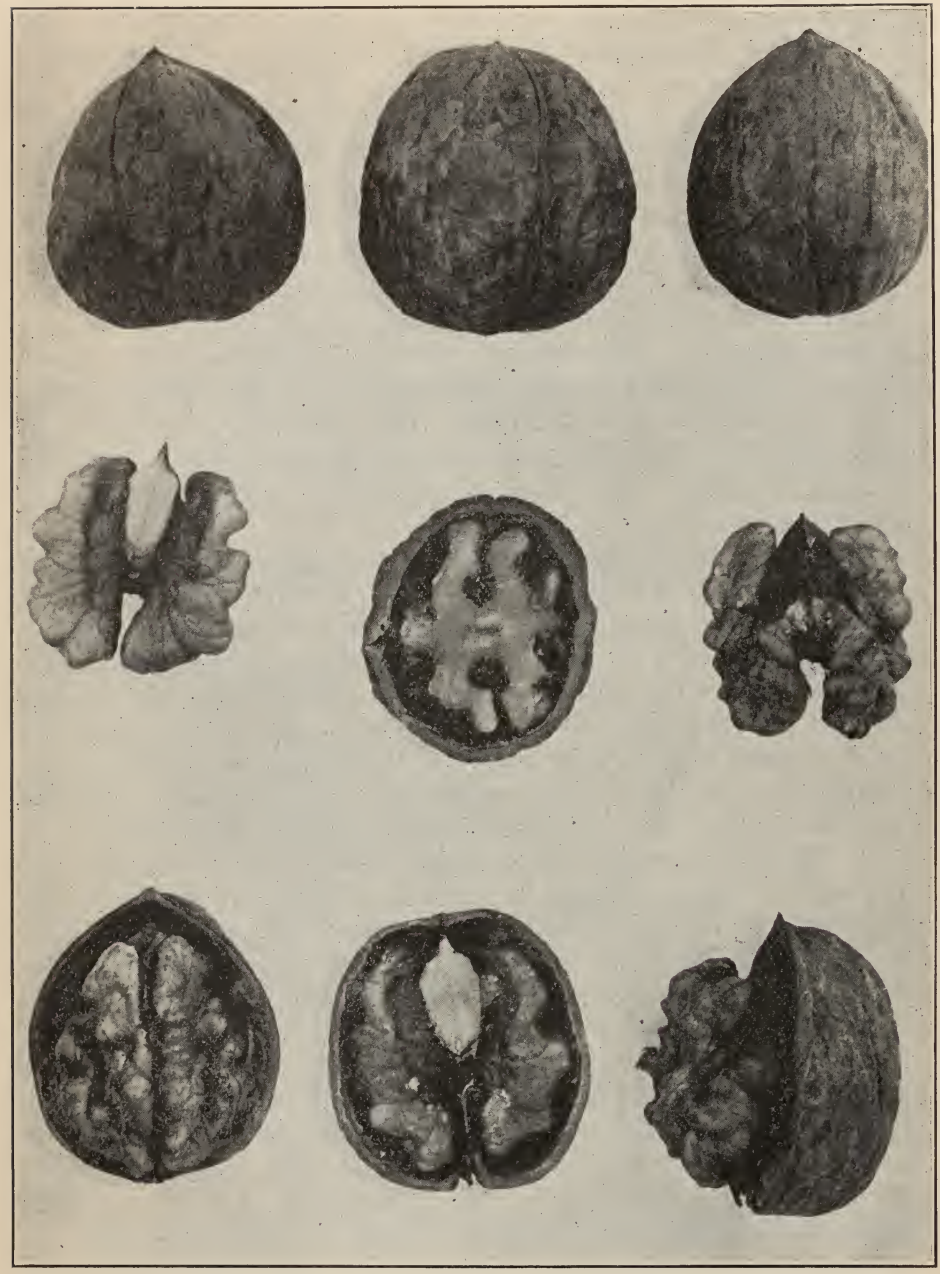


Fig. 53.—Concord walnut, natural size.

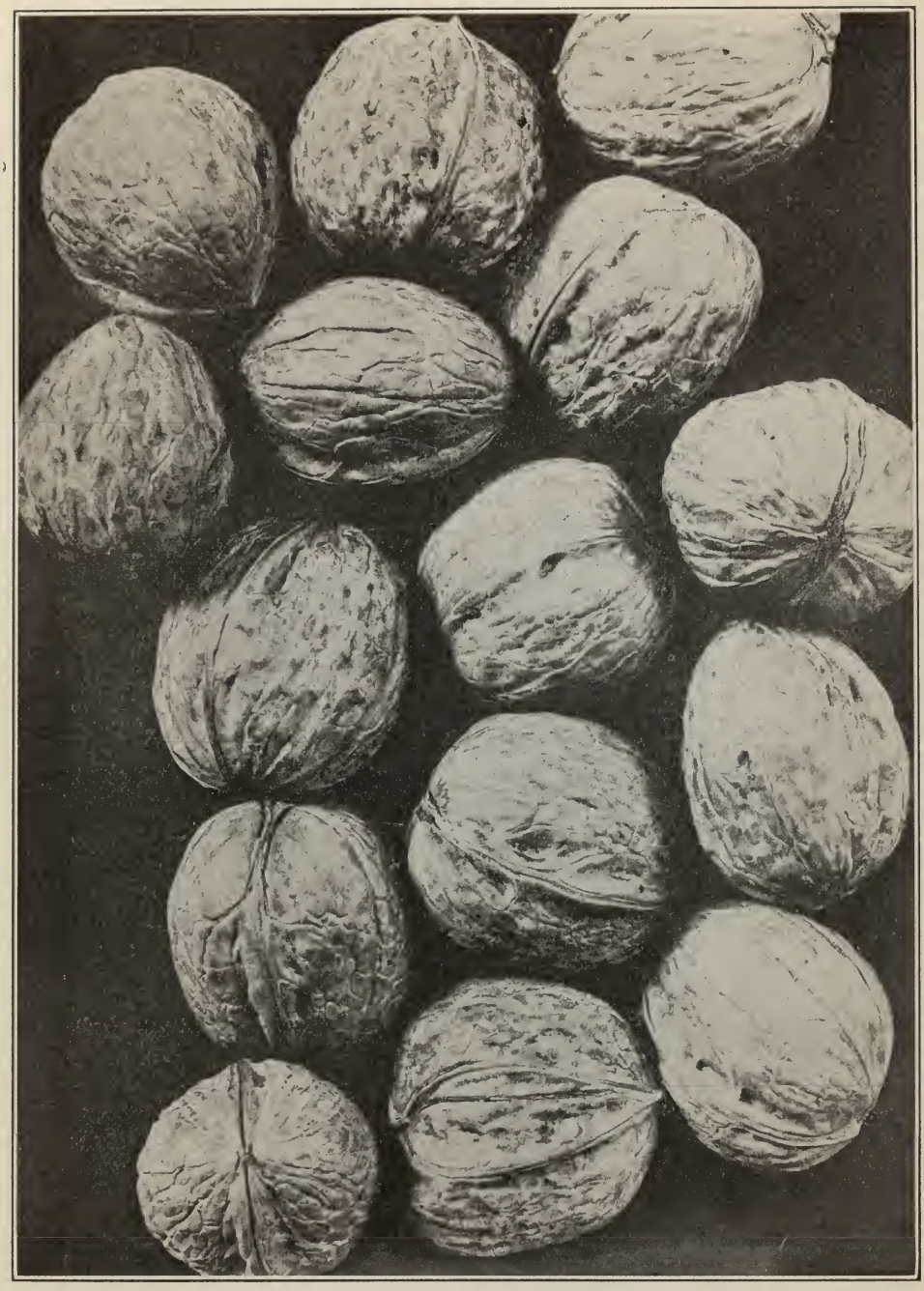


FIG. 54.—Concord walnut, natural size.

and of decidedly good fullness and color of the meat. Against the variety, it may be said that the nuts are of only medium or even rather small size, especially as the trees grow older, and of no more than average quality in appearance. For the southern part of the State the Concord has not been sufficiently tested to justify any positive statement

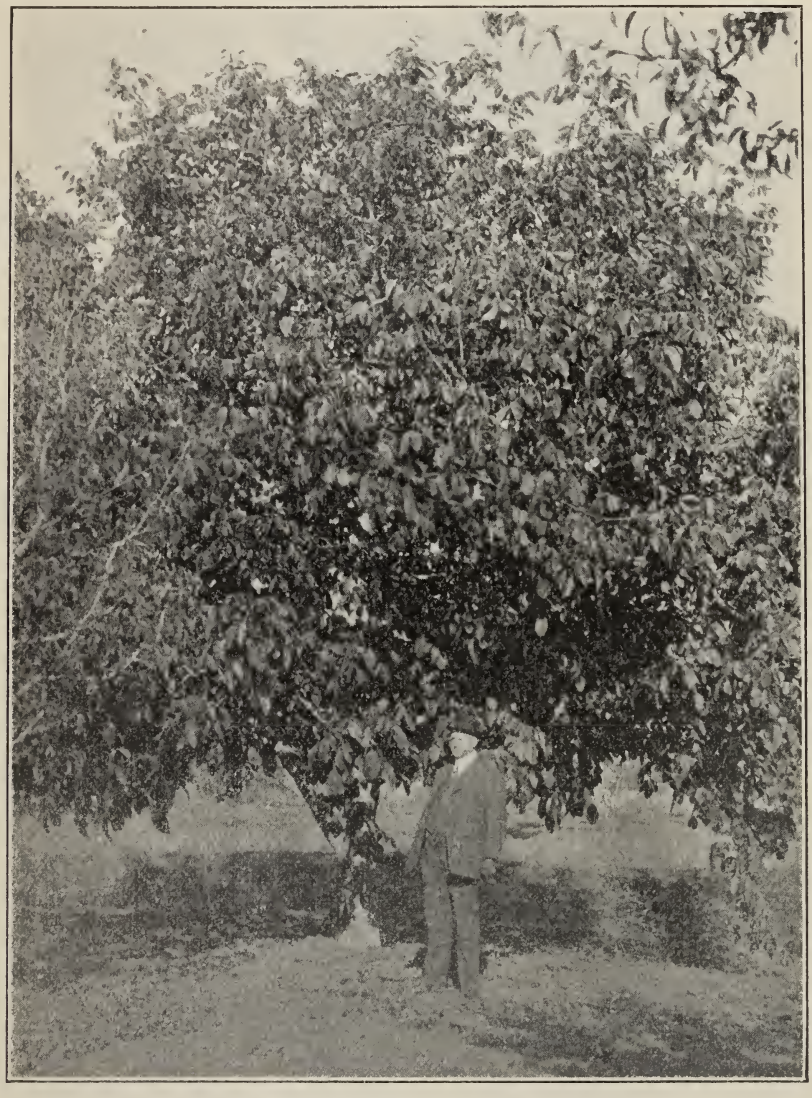


FIG. 55.—Concord walnut, original tree.

concerning its development there. For the north it is reasonably certain that this variety will make a vigorous, quick-growing tree, producing good commercial crops, of full, sweet-meated, not very large nuts, within a reasonable time. It is inferior to Franquette in size and quality of the nuts, but will probably surpass it in production and precocity.

EUREKA.

Origin.

This variety originated in a seedling tree on the Stone ranch, at present owned by Mr. William Holve, one mile south of Fullerton, California. The particular tree stands directly in front of the house by the roadside and is one of a group of about six trees which were planted about 1890 or earlier, from nuts obtained at the old Meek place, near Hayward, California. The parent tree was one of the Persian or Kaghazi type which we have described under that name. The desirable quality of this tree was first appreciated by Mr. E. G. Ware, of Garden Grove, who named the variety Stone's Eureka, about 1903.* Mr. D. C. Disher of Garden Grove was associated with Mr. Ware in first propagating and calling attention to the merits of this variety. Up to about 1909 very few Eureka trees were propagated except by Mr. Disher and almost all of his were bought by Mr. C. W. Leffingwell, Jr., and planted on his ranch at East Whittier. Messrs. Ware and Disher planted a few on their places at Garden Grove, and Mr. J. B. Neff of Anaheim also had a few of the earlier trees. There are also a very few of these on some of the ranches in the vicinity of the Stone place where the variety originated. In 1909 Mr. Neff top-grafted about 200 orchard trees, mostly Placentia Perfection, to this variety, and the Experiment Station, through the Whittier Laboratory, began sending out Eureka scions for trial to all parts of the State. In 1911 several nurserymen began listing this variety.

NUT.

Size.

Large. Average $1\frac{1}{8}$ by $1\frac{5}{8}$. Many larger.

Form.

Decidedly elongated, with parallel sides; apex and base of equal breadth, or a little thicker at the apex. Rather rectangular or square in end view. Nuts very blunt, with a little more taper at the base than at the apex.

Surface.

Quite smooth, sutural ridges not prominent except at one point a little toward the apex from the middle.

Color.

Dull, light brown, more attractive when bleached or well washed. Very pleasing to the eye when properly bleached.

Uniformity.

Pronounced. One of the strong qualities of the variety. Nut easily distinguished from any other kind.

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*The *Pacific Rural Press* of January 23, 1904, contains what appears to be the first printed mention of this variety.

Cracking Quality.

Shell hard, rather thick, heavy and very strongly sealed. Never splitting open in handling and not easily cracked with the fingers. Meat easily extracted after cracking.

Pellicle.

Straw color, light and attractive.

Meat.

Full and heavy in good specimens. Averages 45 to 50 per cent of total weight of nut, while the shell is extra heavy.

Flavor.

Excellent. Particularly sweet.

TREE.

Foliation Period.

Medium late. About midway between the early blooming varieties like Chase and Placentia Perfection and the very late ones, such as Franquette. A little later than Concord. Earlier in the north than in the south.

Growth.

Extremely vigorous and rapid, especially in nursery and top grafts. Young trees form a few large leaders, with few fruit spurs until the fourth or fifth year. The smooth bark of the trunks of young trees has a yellowish color. The bark on the trunk of the older trees is cracked or furrowed up and down in a manner characteristic of the Kaghazi type.

Foliage.

Very thrifty and abundant, shading the nuts well.

Harvest Season.

A little later than that of the earliest varieties, considerably earlier than Franquette.

Precocity.

Not marked in southern California. About two years later than Chase, Placentia Perfection, etc., in coming into bearing. Experience in the northern part of the State indicates that Eureka is more precocious there than in the south.

Production in Older Trees.

Can only be judged from the original tree. This was said to be averaging somewhat over 200 pounds of nuts per year when sixteen to eighteen years of age, before being heavily cut for scions. The tree is positively known to us to have borne this amount in at least one or two years. From the oldest propagated trees of the variety, Mr. E. G. Ware obtained a few nuts during the fifth year after planting and as high as 20 pounds on some trees during the seventh year. In Mr. C. W.

Leffingwell, Jr.'s grove the first nuts were produced in the fourth year after planting and only a very few trees had nuts on them during that year. During the fifth year there was a sprinkling of nuts on every tree, but hardly enough to be measured in pounds. In the vicinity of Stockton, Eureka top-grafted on good sized black walnut trees by Dr. W. W. Fitzgerald produced a few nuts the first year after grafting and quite a sprinkling of them during the following season. Mr. Ely Hutchinson of Concord had the same experience. The variety has shown a wonderful vigor of growth wherever tried in this way.

Susceptibility to Blight and Other Troubles.

From all experience with Eureka we are justified in stating that this is the most resistant to blight of any variety thus far observed. That it does not merely escape the blight by late blooming, but actually resists it to a considerable extent seems to be the case from the fact that still later blooming varieties are more susceptible to blight than Eureka. It may be said of this variety that it has been very thoroughly tested in regard to blight resistance, which is not the case with many kinds which are advertised as immune. The original tree stands in a locality where the disease has prevailed for many years and caused immense losses. The tree is surrounded on all sides by seedling walnut groves in which the blight has occurred at its worst. The statement, therefore, that no sign of the disease has ever been seen on this tree seems a strong one, yet if not absolutely true, it is certainly a fact that year after year, when seedling groves all about were very badly blighted, no blight could be found upon this tree, and so far as we know in five years' observation it has never been affected to any appreciable extent by the disease. While young trees planted in other localities and in new localities may possibly lack this absolute immunity from blight, it is certainly true that the Eureka has shown the greatest freedom from the disease under the most severe test of any variety which is now before the public. In this respect it has fully justified the name given to it by Messrs. Ware and Disher nearly ten years ago in their search for a blight-resistant variety. In respect to other troubles than blight, the Eureka has thus far been entirely free from perforation, and it is not likely that the variety will ever develop this trouble on account of its strong, thick shell. It is also free from sunburn on account of its abundant foliage and thick husk, and in every way the variety is healthy, thrifty, and free from disease.

GENERAL REMARKS.

The Eureka comes very close to satisfying the requirements of an ideal walnut for California. It is a fine, large nut of strikingly handsome appearance, extra full meat and weight, perfectly sealed,

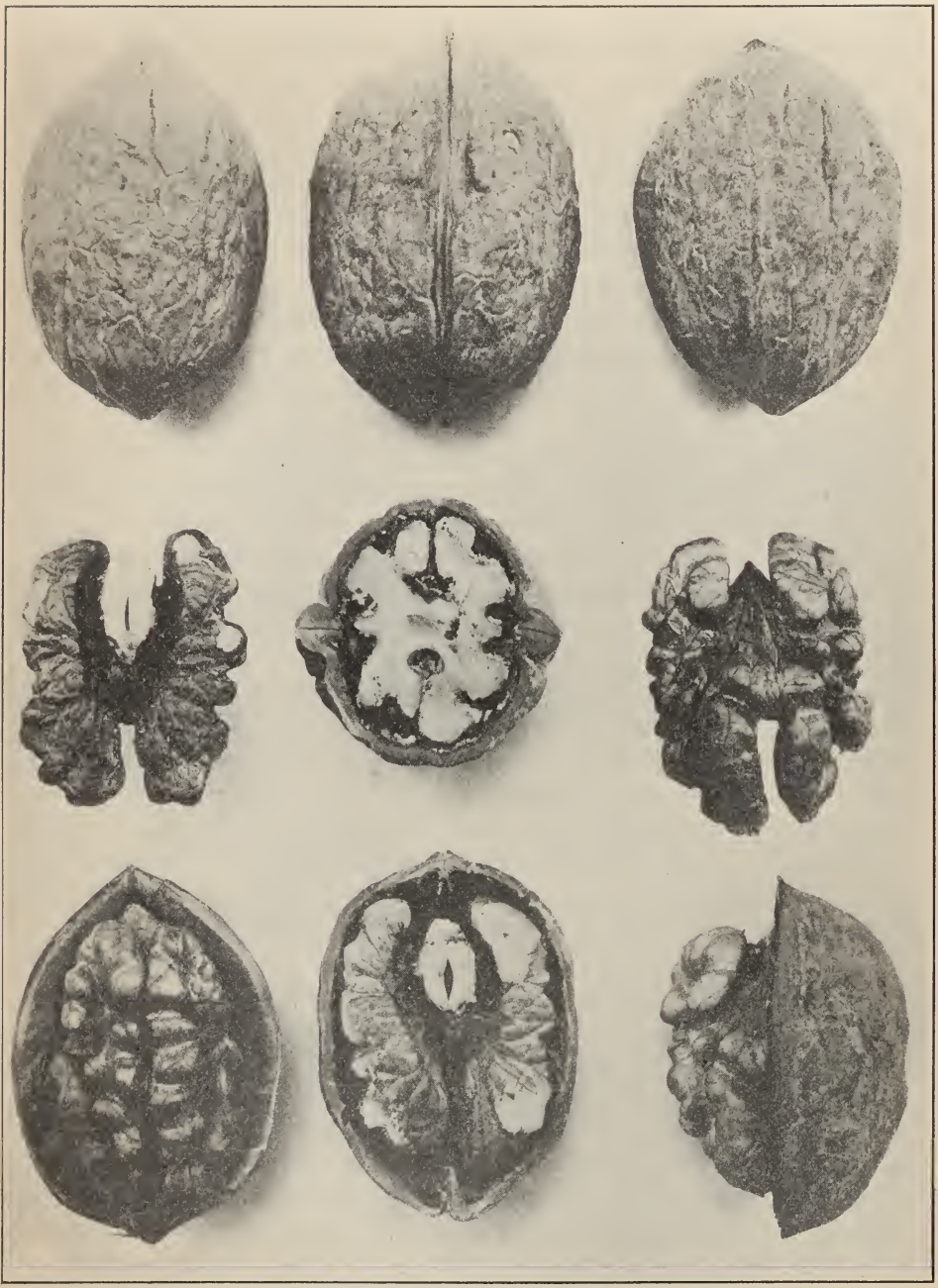

FIG. 56.—Eureka walnut, natural size.

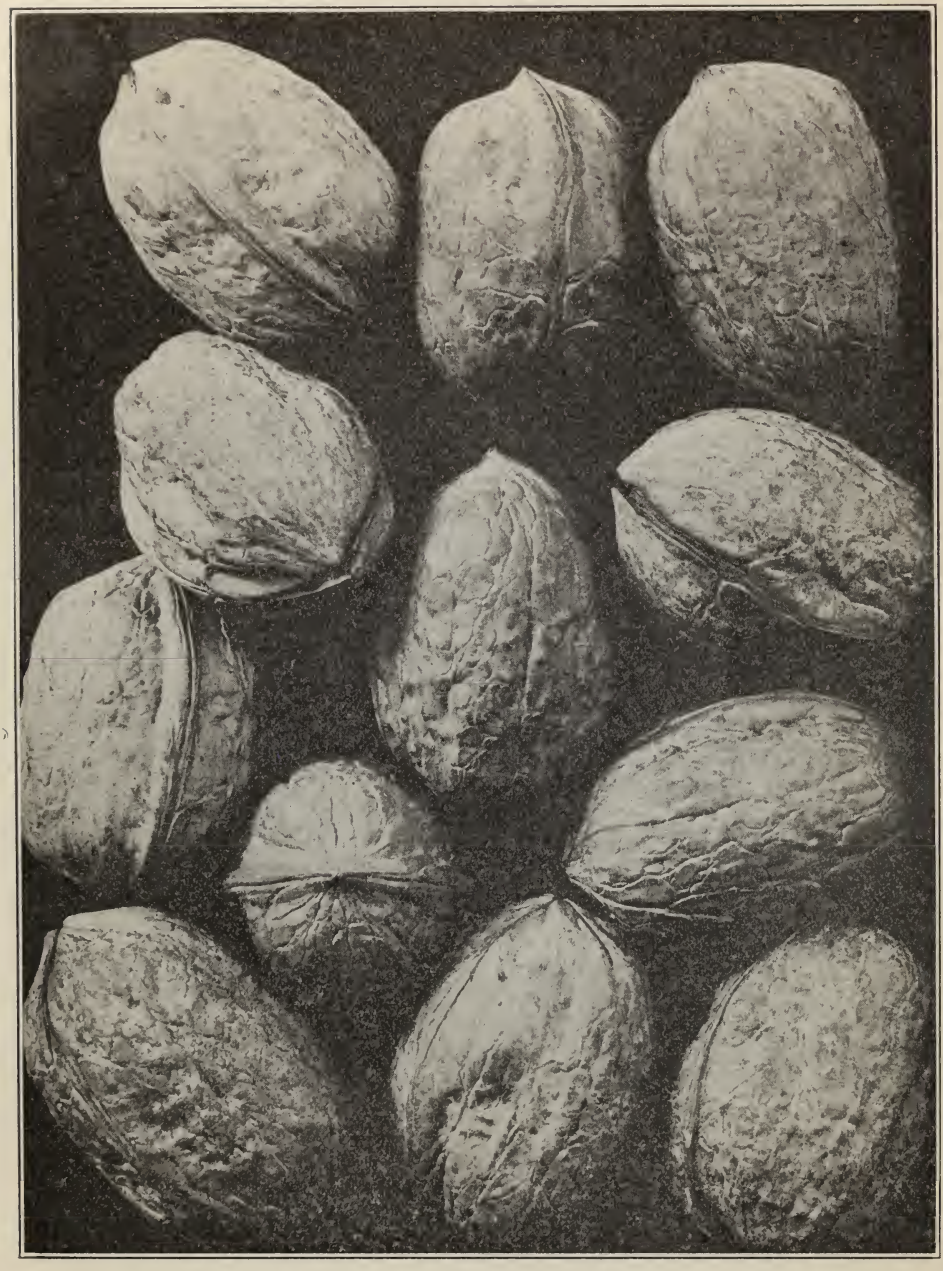

Fig. 57.—Eureka walnut, natural size.

light-colored meat, fine flavor, marked immunity to disease, a strong, vigorous grower and ultimately a heavy producer. Its worst defect thus far has been a tendency toward a slightly imperfect development of the meat in certain seasons, especially a shriveling of the meat at the basal end of the nut. This has been most pronounced during dry years, on lighter soils and on trees which received little or no irrigation. The same shriveling has usually occurred at the same time in other varie-

Fig. 58.—Eureka walnut, original tree.

ties. The variety is strong as compared with any other southern California kinds in its freedom from blight and perforation, extremely thrifty foliage and growth, large size, uniformity, and attractive appearance of the nuts, especially when bleached, and their strong sealing and heavy weight. While the percentage of meat is slightly lower than in Placentia Perfection and a few other varieties, this is not due to a lesser amount of meat, but rather to the greater weight of

the shell; in other words, Eureka nuts are heavier than those of the same size of any other variety, thus making fewer nuts per pound

Fig. 59.—Eureka walnut tree, three years old.

or more pounds per sack. Compared with Franquette or any other French variety or California variety of French origin, Eureka is a more precocious and heavier bearer, more thrifty in growth and foli-

age, equally proof against ordinary spring frosts by lateness in its foliation period, and considerably earlier in maturing its nuts in the fall. In the south it is less precocious than the best southern varie-

FIG. 60.—Eureka walnut tree, six years old.

ties, but promises ultimately to exceed most of them in production. In the north it seems as precocious as any variety yet tested commercially. The size of its nuts is well sustained, contrary to the case in some of the other varieties. From present information this variety

appears especially promising in the northern part of the State, and the expectation is well justified that Eureka may become the best variety for the northern districts. In the south the variety has disappointed some on account of its slowness in bearing as compared with Placentia Perfection, but it is significant that those who have known the variety best and longest, walnut growers of the immediate locality of the original tree, are very enthusiastic about the Eureka and express themselves very strongly in its favor. In all events, present knowledge seems to indicate the particular adaptability of this variety to the northern part of the State and to fairly heavy, well irrigated land.

FRANQUETTE.

Origin.

A French variety said to be nearly two hundred years old. First introduced into California by Felix Gillet in 1871. Most of the Franquettes at present growing in the State have been derived from Gillet's importations, although the variety has possibly been brought from France by others in one or two instances. The present standing of the Franquette as the leading northern California and Oregon variety is based on the success of the Vrooman grove at Santa Rosa. This sixty-acre walnut orchard was planted by the late Mrs. Emily Vrooman at a time when commercial walnut growing north of Santa Barbara County was absolutely unknown, and as a result of Mrs. Vrooman's investigation of and confidence in the Franquette the qualities of this variety are well established. In more recent years the Franquette has been extensively taken up by the Leibs of San José, who have become the leading exponents of this variety. Through the influence of the Oregon Nursery Company, who bought the scions and nuts from the Vrooman orchard for a period of several years, the fame and popularity of the Franquette have been largely extended and many others have become familiar with and planted the Franquette on a considerable scale, both in central and northern California and Oregon. In southern California there is a large tree on the old Experiment Station grounds near Pomona, Mr. Neff of Anaheim has a few trees top-grafted to Franquette, and there are several young and top-grafted trees at the Whittier laboratory and at the Pasadena City Farm.

NUT.

Size.

Medium to large. Well sustained on old trees.

Form.

Decidedly elongated and pointed. Base much broader than apex.

Surface.

Medium smooth. Sutural ridges quite prominent.

Color.

Light yellowish brown.

Uniformity.

Strong. The uniform and characteristic shape of the Franquette nuts makes them easier to identify than those of almost any other variety.

Cracking Quality.

Nuts strongly sealed, but quite thin shelled so that they are readily cracked.

Pellicle.

Pale yellowish tan, giving the meat a very light colored, attractive appearance.

Meat.

Moderately plump and filling the body of the shell fairly well. The shell is considerably longer than the meat, leaving a hollow space within the apical point of the nut.

Flavor.

Sweet and free from bitterness, with a characteristic nutty flavor approaching that of a hickory nut. The consistency of the meat is also characteristic, being unusually soft or oily.

TREE.

Foliation Period.

Very late. The latest of any important variety in California. Often two to three months later in coming out in the spring than the earliest varieties. The Franquette is also noticeably early in dropping its foliage in the fall so that its seasonal period of growth is comparatively short.

Growth.

Fairly vigorous and rapid, but decidedly less so than that of many other varieties. The best growth of the Franquette is seen in comparatively cool, moist localities, as for instance in the coastward region of the central and northern parts of the State. In the south and in the interior, especially without irrigation, the Franquette is of slower growth.

Foliage.

Abundant and thrifty, but developed late and shed early in the season.

Harvest Season.

Late. One of the undesirable features of this variety.

Precocity.

Not pronounced. The Franquette is one of the slowest in coming into bearing.

Production in Older Trees.

So far as can be judged by the oldest Franquette trees in the State the Franquette is a regular and consistent but not a heavy bearer. Trees

ten to fifteen years of age have averaged not over 40 pounds per year and 100 pounds is probably a maximum production for large, mature

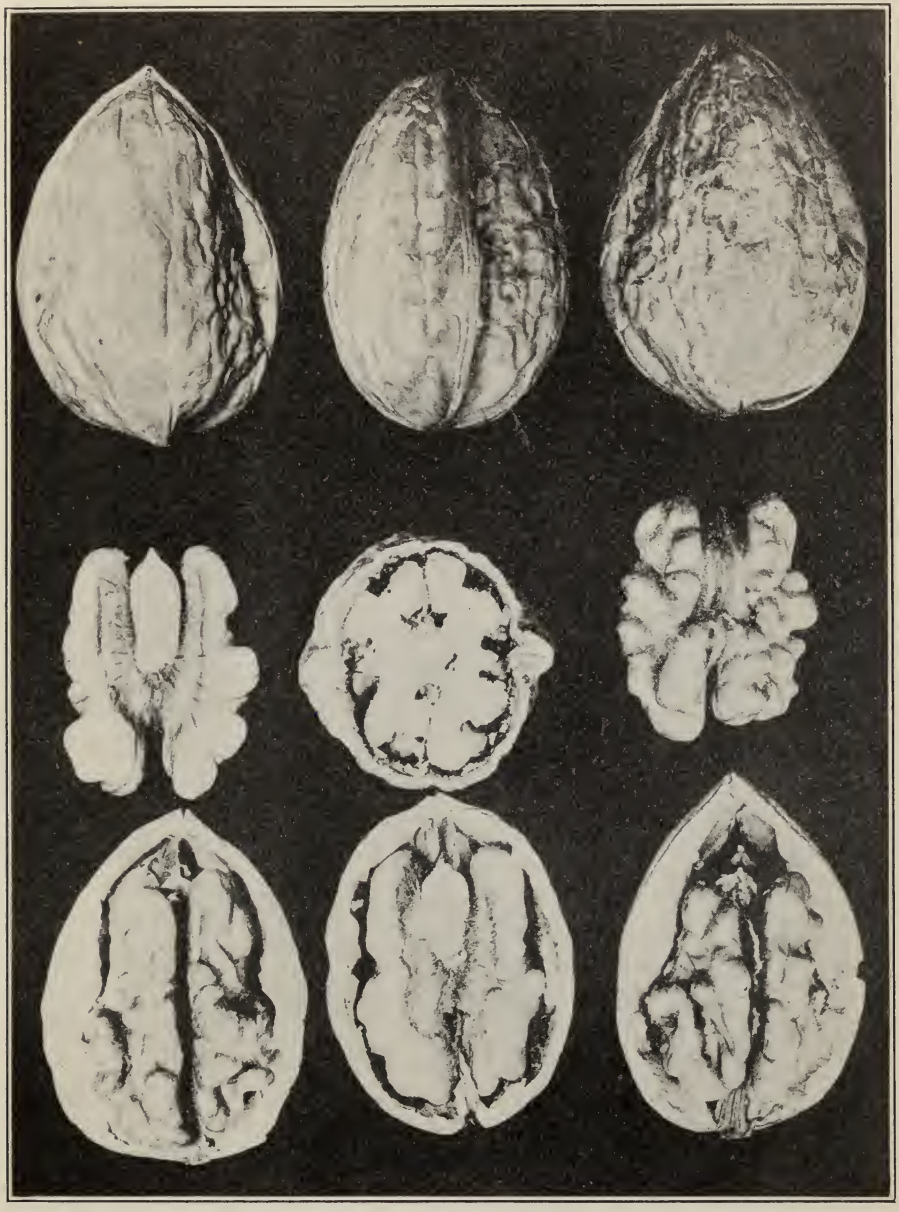

Fig. 61.—Franquette walnut, natural size.

trees of this variety. Groves of nursery-grafted trees in their sixth year after planting have scarcely averaged 10 pounds per tree.

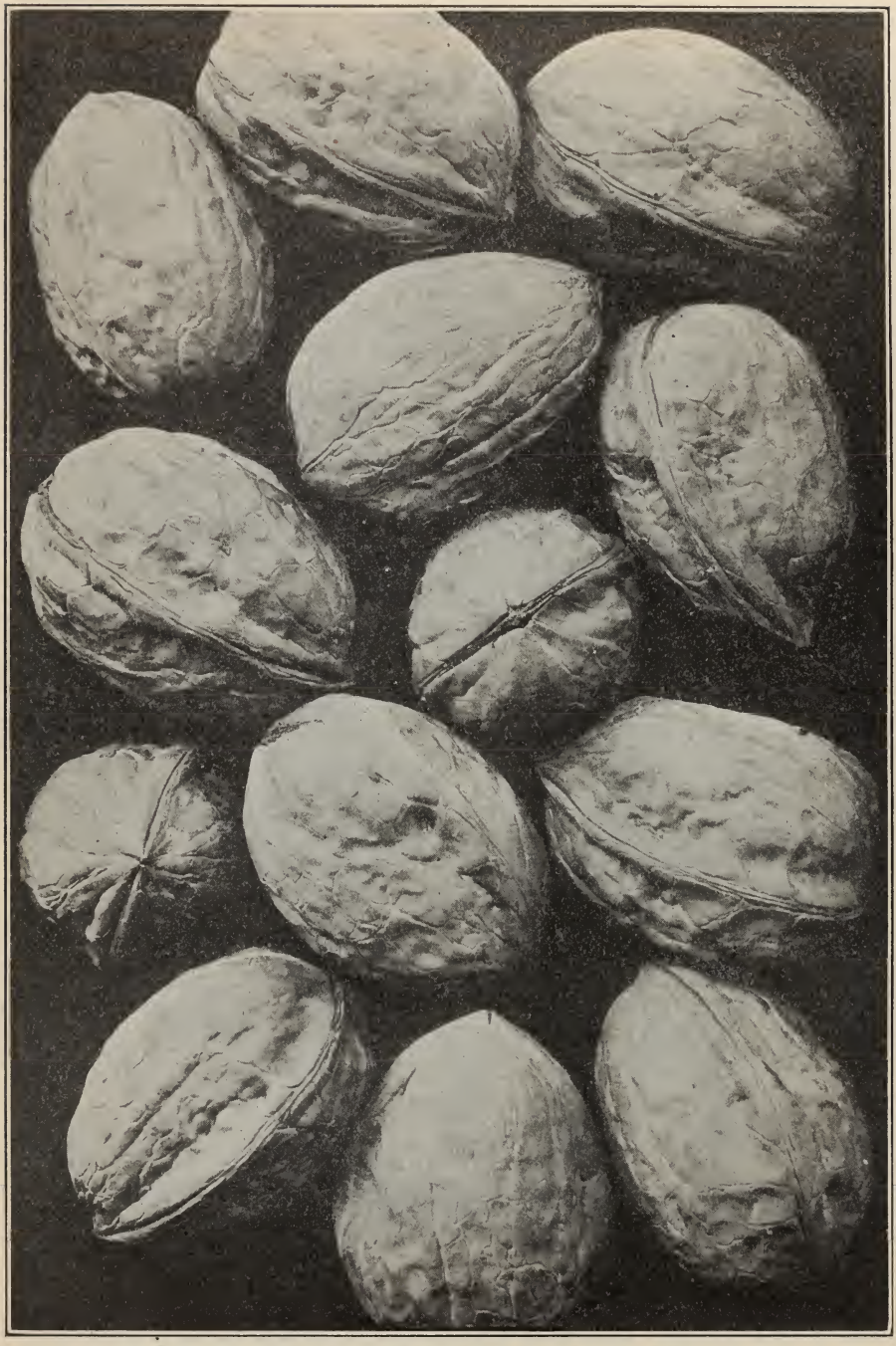

FIG. 62.—Franquette walnut, natural size.

Susceptibility to Blight and Other Troubles.

The Franquette is noticeably free from blight in most cases on account of its extreme lateness in coming out in the spring. The variety appears to have very little actual resistance to the disease, since in foggy localities the nuts and twigs sometimes blight quite badly. The thick husk and abundant foliage protect the nuts from sunburn to a very large extent, and the variety is not especially susceptible to any other trouble, except that in some years the meat shrivels rather badly.

Fig. 63.—Franquette walnuts, Vrooman grove.

GENERAL REMARKS.

The Franquette is undoubtedly our best proven variety for central and northern California and has one great advantage over any other variety for that section, that it has been thoroughly tested and its merits and demerits well established. It is thus possible to judge the variety more critically than can be done with any other northern variety, and for this reason our description of it may sound more unfavorable than the Franquette really merits. As regards quality of the nut, this

variety may be taken as a standard, as it is undoubtedly the best of any variety which has been widely tested in California. Its characteristic and uniform shape, light, attractive color, both of shell and meat, firm sealing yet easy cracking quality, and the particularly pleasing flavor

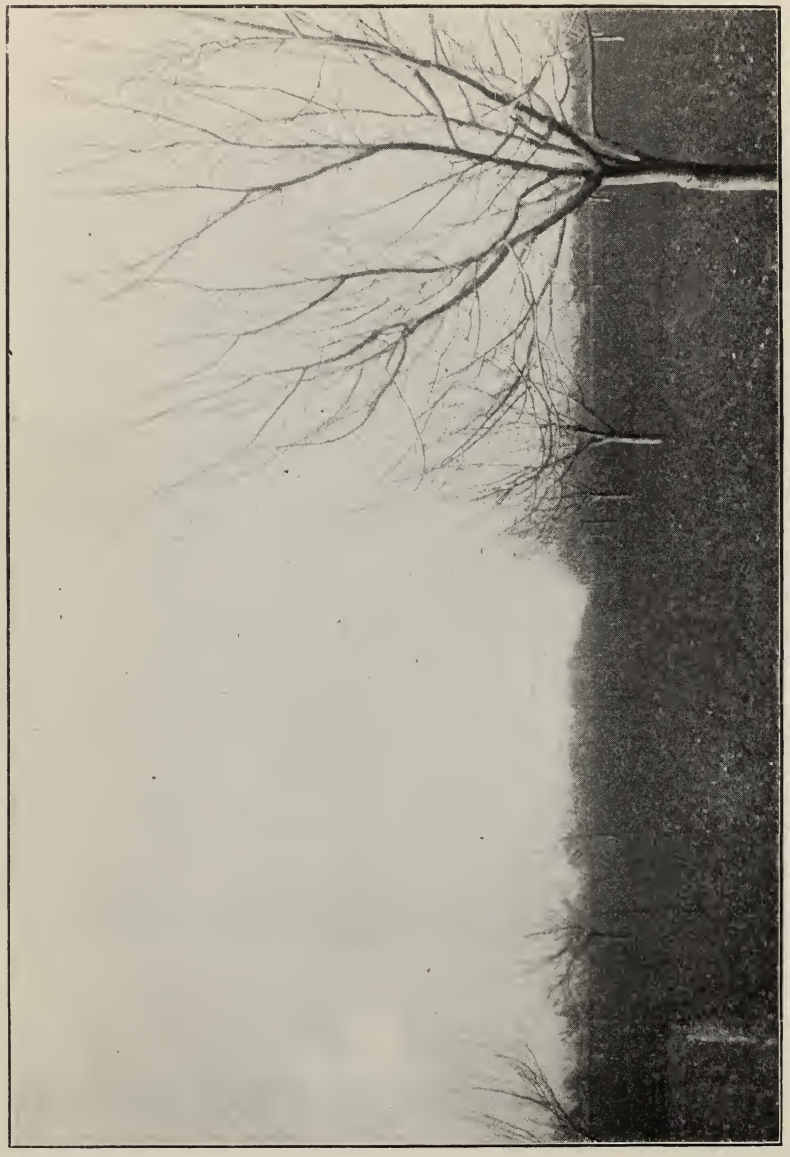

FIG. 64.—Franquette walnut trees, seven years old, Vrooman grove. (Courtesy Oregon Nursery Company.)

and consistency of the meat all go to make the Franquette nut one of the very highest quality. The variety is also strong in freedom from blight and spring frost injury on account of its very late season of coming out. The most prominent faults of the variety are its slowness in

coming into bearing, the late period of maturity of the nuts in the fall, and the fact that the tree is by no means as heavy a bearer as should be looked for in an ideal variety. All in all, then, we may say that the Franquette is a variety of unusually high quality and rather poor production. For southern California, where it has been tested to some extent, we do not believe that this or any other extremely late variety is to be considered. Farther north it is undoubtedly true that for the ultra-conservative planter, at least, no other variety can be considered as safe as this, since its behavior in orchard form can be very closely forecasted. Franquette nuts have commonly sold for nearly twice the price of southern California seedlings, which offsets to some extent the light bearing and lack of precocity of the variety.

PLACENTIA.

(Placentia Perfection.)

Origin.

Originated in Placentia, near Fullerton, California, as a seedling of the Santa Barbara Soft Shell type. The original tree stood in an orchard of Geo. Hind & Company, about one mile north of the Placentia schoolhouse; the first propagation of the variety was done by Mr. Hind about 1893, and the variety received its name from this gentleman. Mr. J. B. Neff of Anaheim was the first to plant any considerable acreage of Placentia Perfections, the first trees which he bought of Hind & Company being bench-grafted on piece roots, using about six to ten inches of the root and making three to four nursery trees from one root. In former years Mr. Neff sold many scions and seed of this variety to nurserymen over the State, as much as 1,600 pounds of nuts and 20,000 scions in one season. In later years he refused to sell either seed for planting or scions, on account of the susceptibility of this variety to walnut blight. He also grafted over all his younger Placentia trees to the Eureka variety on account of the blight.

At present there seem to be in southern California two fairly distinct types of the Placentia walnut, even among trees which are supposed to have been grafted from pure stock. These two types, while in most respects identical, differ in that the nut of one is quite elongated while the other has a decidedly round nut. The quality of the nut in the two types is apparently identical, as well as the general characteristics of the tree. Mr. Neff's trees, which are certainly of the purest original strain, bear nuts of the round type, but the majority of the younger groves of this variety in southern California bear the longer type of nut, which is that which we are about to describe. This latter type is more variable in form and smoothness of the nuts than the other. That this variation has occurred in the grafted progeny of one original tree rather than by mixing of the stock seems very possible, as the different types are too much alike to be considered entirely distinct varieties.

NUT.

Size.

Medium, averaging $1\frac{1}{8}$ by $1\frac{1}{4}$ by $1\frac{1}{2}$ inches. Runs largely to average size, with few very large or very small nuts.

Form.

Regular, oval, somewhat elongated; base and apex nearly equal in breadth. Flattened, with greater diameter at right angles to the sutures.

Surface.

Quite smooth. Sutural ridges not especially prominent.

Color.

Light neutral brown, mottled with gray, giving the nut a distinctly pinkish cast.

Uniformity.

Not especially strong. Nuts quite uniform in size, but varying considerably in shape and smoothness. Some quite elongated, others nearly round, some quite rough.

Cracking Quality.

Nuts poorly sealed, causing them to open very readily between the fingers or when exposed to the sun. Shell thin and strong. Septum almost free from the shell, so that the nut can be very easily opened with the fingers and the whole meat taken out intact.

Pellicle.

Light tan colored, or very light silvery brown, with a glossy, waxed appearance. Decidedly attractive.

Meat.

Quite smooth, with comparatively few convolutions. Uniformly plump and full, averaging fully 50 per cent or slightly more of the total weight of the nut.

Flavor.

Mild and pleasant, with no pronounced character.

TREE.

Foliation Period.

Quite early. Nearly two weeks later than Chase and the average of the Santa Barbara Soft Shell seedlings. From one to four weeks earlier than Concord and Eureka.

Growth.

Vigorous, making a large, tall tree, the more erect, taller branches standing up from the lower portion in a characteristic manner.

Foliage.

Very abundant and thrifty.

Harvest Season.

Early.

Precocity.

Fair. Commences bearing fairly well while quite young, at least in southern California.

Production in Older Trees.

Very good, but not exceptionally heavy, so far as can be learned from present plantings.

Susceptibility to Blight and Other Troubles.

Badly affected by blight under conditions favorable to the disease. Nuts sometimes badly perforated, especially on young trees. Otherwise, not especially susceptible to disease.

GENERAL REMARKS.

The Placentia Perfection is in many respects the best walnut which has yet been thoroughly tried in southern California, and, all things considered, is entitled to be called the best proven variety for that part of the State. It comes close to being an ideal nut save for two defects, but these are so great as to preclude all idea of considering it a thoroughly satisfactory variety. These defects are the poor sealing of the nuts and the susceptibility of the variety to blight. The nuts crack open badly in ordinary handling, and still more so if exposed to the sun to any extent in drying. In regard to blight, the Placentia Perfection is very susceptible to the disease, which again belies its name. Aside from these two defects, however, the variety is one of high quality and is probably unequaled by any other as a commercial walnut for southern California. It is of a desirable and attractive form and size, heavy and very plump meat running a full 50 per cent or better. The meat is of a very attractive color and appearance and can easily be taken out of the shell whole with the fingers. The nuts are almost invariably well filled, even in seasons when the average quality of walnuts in this respect is very poor. The tree is thrifty and vigorous, one of the easiest to propagate by grafting, quite precocious, and becoming large and well formed while still comparatively young. In regard to production, the variety is not old enough to be critically judged. Trees in their fifth year from planting in the orchard have produced from twelve to twenty pounds of nuts, which is as good as almost any other variety will average, and better than most. We know of one grove which produced slightly more than one ton of nuts per acre in its tenth year, which is a very satisfactory yield compared with present groves, although by no means up to the possibilities of an ideal variety. Since the Placentia has no immunity to blight and is superior only in the quality of the nut and satisfactory development of the tree, it is probable that varieties will be found among our present seedling trees equally good in these respects and at the same time less subject to the defects mentioned. The Placentia Perfection is usually looked upon in southern California at

the present time as representing the best type of commercial walnut in that section.

The variety has not been much tested outside of Orange and Los

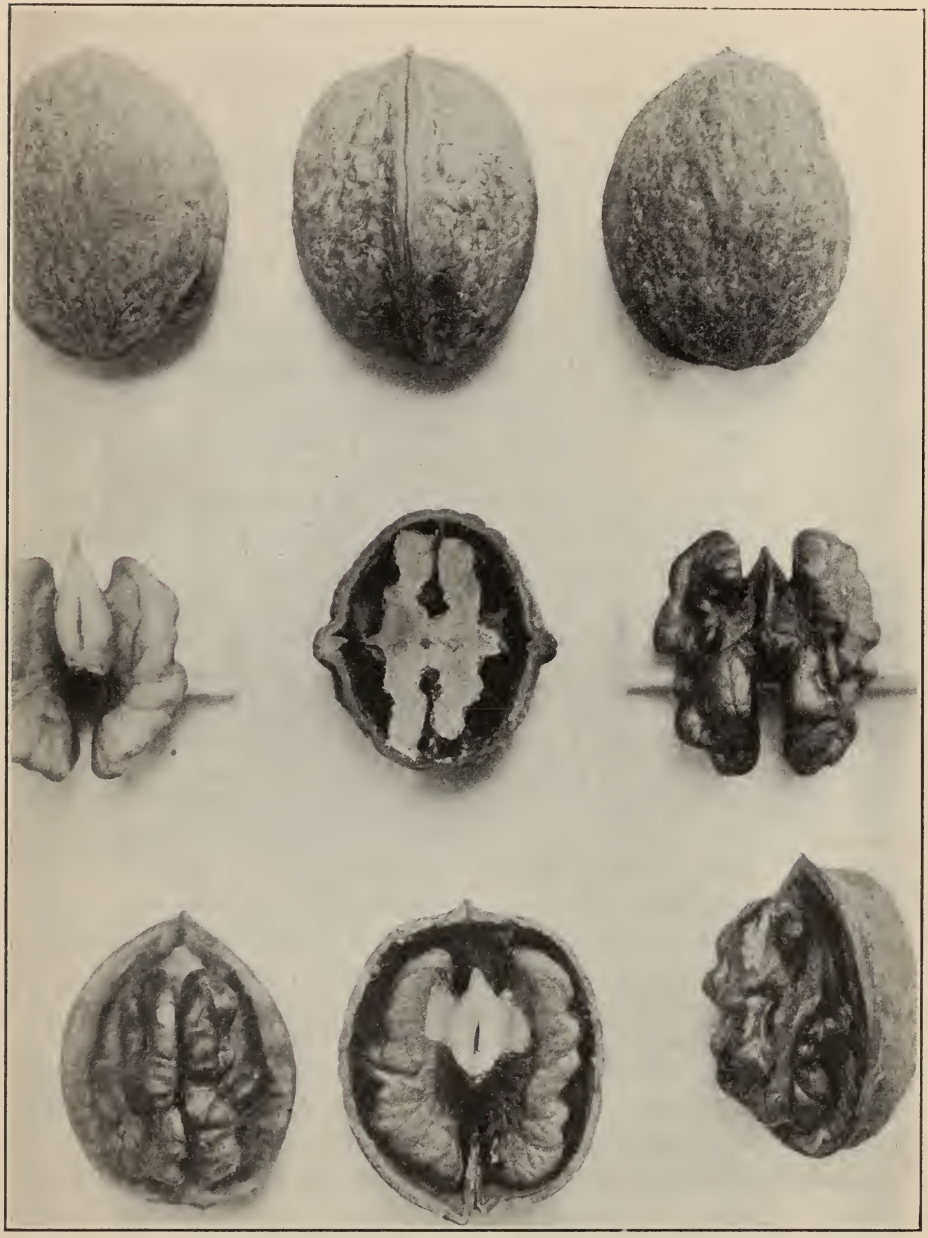

FIG. 65.—Placentia walnut, natural size.

Angeles counties. In the central and northern portions of the State no experience is available upon which to base an opinion as to its merits

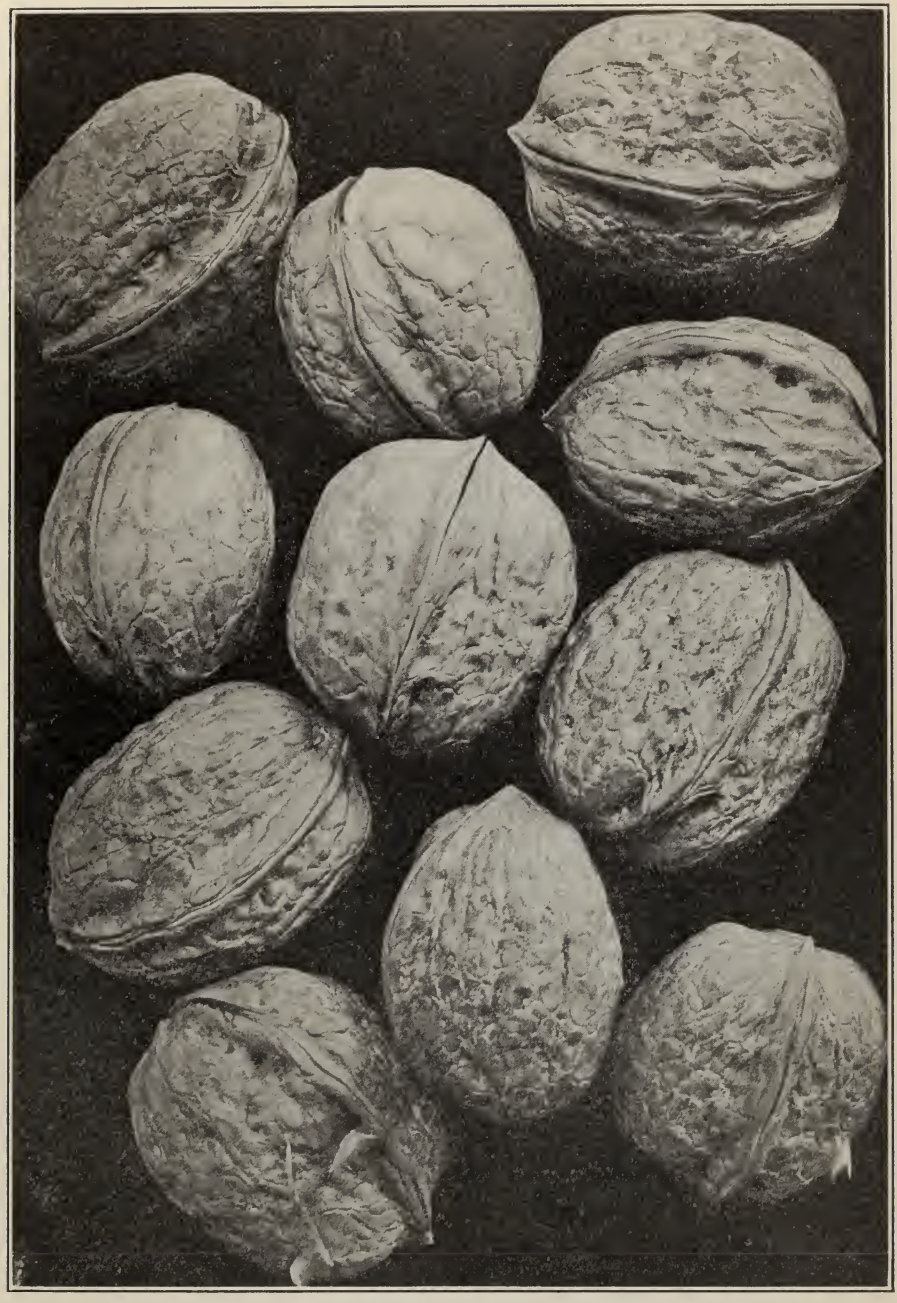

Fig. 66.—Placentia walnut, natural size.

FIG. 67.—Five-year-old Placentia tree on southern California black root.

or the advisability of planting it in those localities. It certainly should not be planted in localities where the blight is very prevalent, on account of fog and moisture in the spring and early summer. Farther inland, as for instance in the Mount Diablo country and the dryer portions of the other coast valleys, and in the Sacramento and San Joaquin valleys as far as walnut culture may prove feasible, the variety is worthy of considerable consideration, especially in regions not too much subject to late spring frosts. In the latter case the Placentia probably blooms too early to be worthy of consideration. There are a few young trees of the variety in the northern portion of the State, but they are scarcely old enough to be critically judged. In growth and general development they are doing very well but have not yet begun to fruit abundantly. Given freedom from late frosts and conditions not too favorable to blight, there is no apparent reason why the Placentia should not do as well in the north as in the south.

PROLIFIC.

(Disher's Prolific, Ware's Prolific.)

Origin.

This variety originated in a Santa Barbara Soft Shell seedling tree at Garden Grove, Orange County, California, which was selected by Mr. D. C. Disher as being worthy of propagation. According to Mr. E. G. Ware, who was closely associated with Mr. Disher, the tree was first selected on account of the desirable form and size of the nuts rather than for the quantity, which the present name of the variety implies. It was found, however, that after young trees planted in orchard form came into bearing they had a pronounced tendency toward early and heavy bearing, from which the present name of the variety is derived. Mr. Disher propagated a considerable number of trees of this variety, mostly by budding on the southern California black root, and they have been planted in orchard form to some extent, the oldest being now in about their sixth year since planting in the orchard. Mr. C. W. Leffingwell, Jr., has a considerable number of the trees upon his ranch at East Whittier, Mr. Ware has five acres of six-year-old trees, and there are a few other orchard plantings of this variety in the southern part of the State. The variety has also been recently introduced into the north, but cannot yet be judged in that part of the State.

NUT.

Size.

Rather large on all the young trees of this variety and apparently well sustained on the original tree.

Form.

Oval, quite elongated and decidedly symmetrical. Base and apex of equal breadth, very obtusely pointed at both ends.

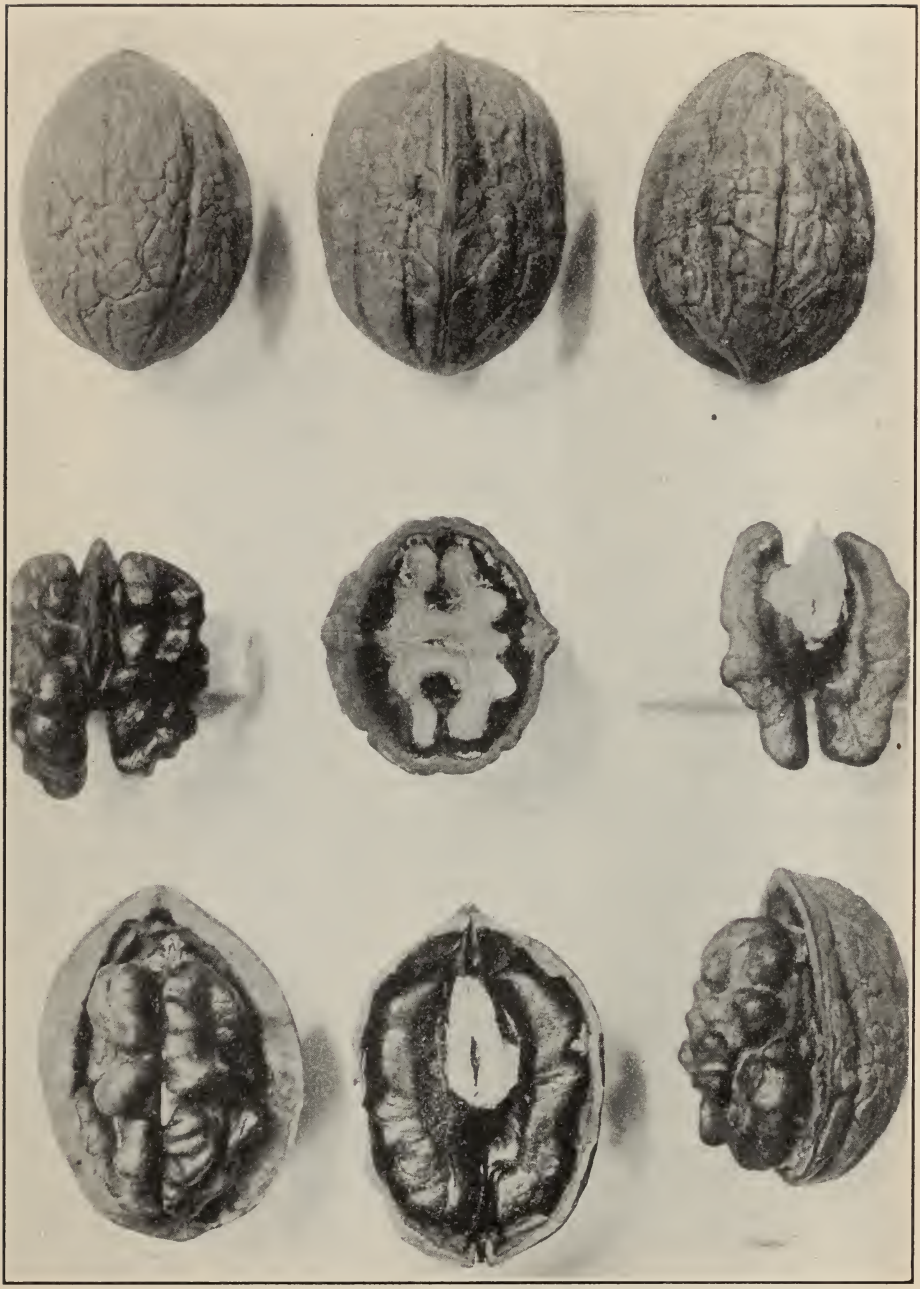

FIG. 68.—Prolific walnut, natural size.

Surface.

Quite smooth, with several quite conspicuous longitudinal seams or grooves which give the variety a characteristic appearance.

Color.

Dull light brown, requiring bleaching for the best appearance.

Uniformity.

Quite strong, both in size, shape and surface.

Cracking Quality.

Poorly sealed at the apex, so that the nuts open easily.

Pellicle.

Amber to dark brown, or in many cases nearly black after exposure to rain. The weakest quality of this variety.

Meat.

Decidedly plump and well filled, averaging a full 50 per cent. Equal to the best in this respect.

Flavor.

Mild and pleasant. Sometimes rather musty after exposure to rain.

TREE.

Foliation Period.

Early. Not later than the average of the Santa Barbara Soft Shell seedlings.

Growth.

Fairly vigorous, with a strong tendency toward the formation of fruiting wood, making a low, spreading tree, with a few straggling, upward-growing leaders. Very numerous fruit spurs develop all over the tree as soon as it is established in the orchard.

Foliage.

Abundant and thrifty.

Harvest Season.

Early.

Precocity.

The strongest of any well tested variety. During the first ten years in the orchard will probably produce at least twice as many nuts as any other southern variety and many times more than any of the French varieties or their derivatives.

Production in Older Trees.

The original tree of this variety stood in a grove of Santa Barbara Soft Shell seedlings and was not selected as being a tree of unusually heavy production. The chief merit of the Prolific in regard to production appears to be its decided tendency toward heavy bearing from about the third to the tenth year in the orchard as compared to other varieties. Mr. Ware's grove averaged about 20 pounds of nuts per tree

the fifth year and 1,000 pounds of dried nuts per acre in the sixth season after planting in the orchard, which crops may be considered extremely satisfactory. A tree of our own, likewise in its sixth year,

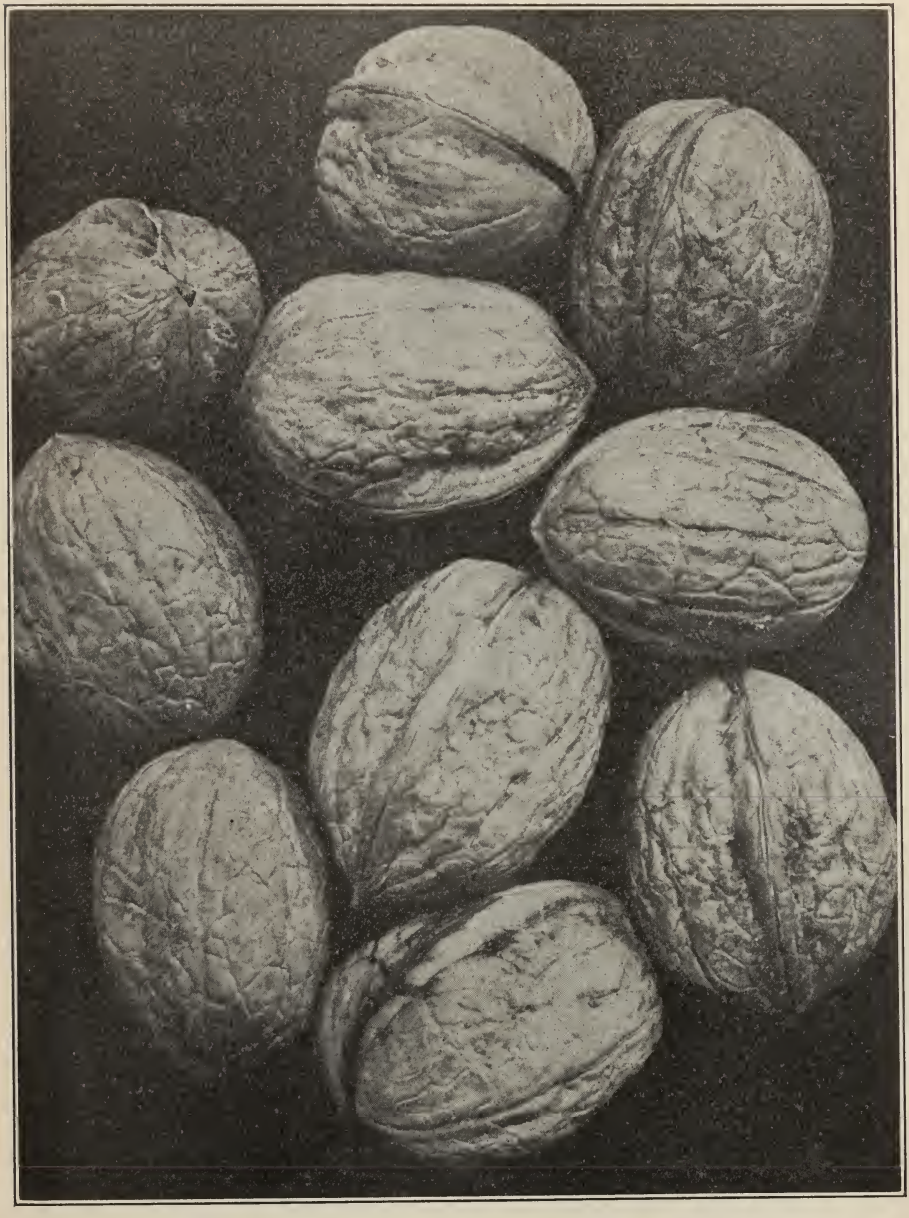

FIG. 69.—Prolific walnut, natural size.

produced 35 pounds of nuts, whereas our best Placentia Perfection of the same age and nearly twice as large as the Prolific tree produced

Fig. 70.—Four-year-old Prolific walnut tree. Note abundant fruit spurs.

less than 20 pounds. The heavy, early bearing of this variety is well established.

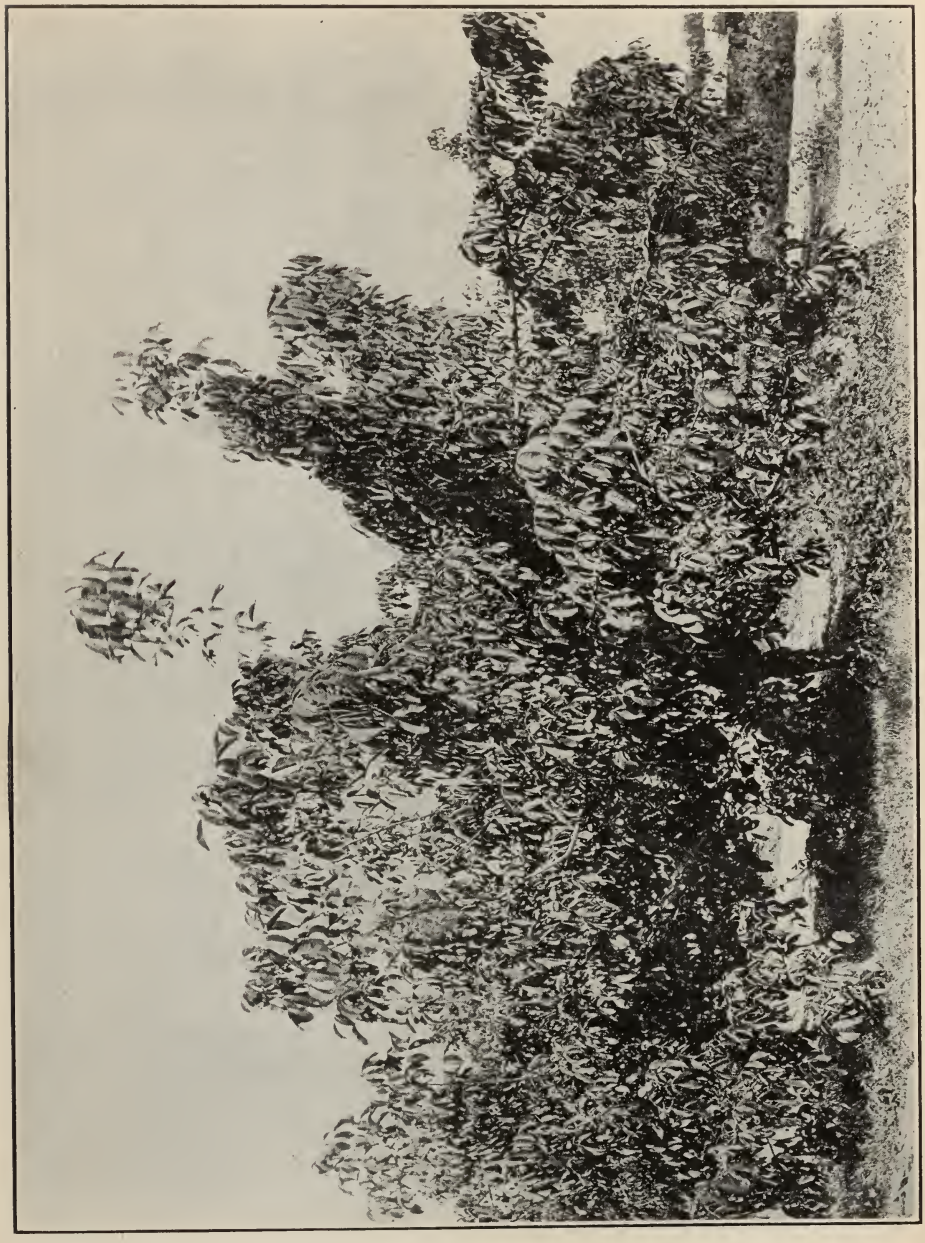

FIG. 71.—Six-year-old Prolific walnut tree, averaging about 50 pounds of nuts per tree.

Susceptibility to Blight and Other Troubles.

This variety has no particular resistance to blight but is affected by the disease as badly as the average of our soft-shell seedlings. It is also of about average quality as regards sunburn and other injurious influences.

GENERAL REMARKS.

The Prolific is worthy of special consideration on account of its marked precocity in bearing. This does not mean simply the production of a few nuts by trees in the nursery or soon after planting, but more than this it is well established that this variety will come into commercial bearing within three years after planting in the orchard and by the sixth or seventh year will turn off as many nuts as may be reasonably expected from old, mature trees of some of our most prominent varieties. The nut is of excellent size and shape, but badly handicapped on account of its poor sealing, dark colored meat and susceptibility to blight. On these accounts it cannot be considered an ideal variety for permanent planting. It is particularly worthy of consideration for interplanting with such varieties as the Franquette, Eureka, or even Placentia Perfection. It should, however, be remembered that for the northern part of the State the variety has not been tested and therefore its adaptability for interplanting with Franquette in that region cannot be positively stated. If its quality of heavy, early bearing is carried out in the north as in the south there is no question that this variety would pay all expenses, including the purchase price of the land, while Franquette was coming into bearing.

SAN JOSE.

(San Jose Mayette; Wiltz.)

Origin.

This is a Mayette seedling propagated by Felix Gillet and planted near San José some years ago. The variety was first taken up by Mr. Rudolph Wiltz of San José and afterward extensively advertised and sold by Mr. Leonard Coates. One of the first public notices of the variety is found in the *Pacific Rural Press* of January 26, 1907, where Mr. Wiltz gives the name San José to this variety. Mr. Gillet also has an article in the same number upon the same subject.

NUT.

Size.

Large; decidedly above the average of most varieties, although not of abnormally large size.

Form.

Rounded, oval, slightly elongated, very symmetrical.

Surface.

Quite smooth, with rather few quite conspicuous seams and veins.

Color.

Bright yellow tan. Unusually light and attractive without bleaching.

Uniformity.

Strong. Nuts easy to identify by their shape, size and color.

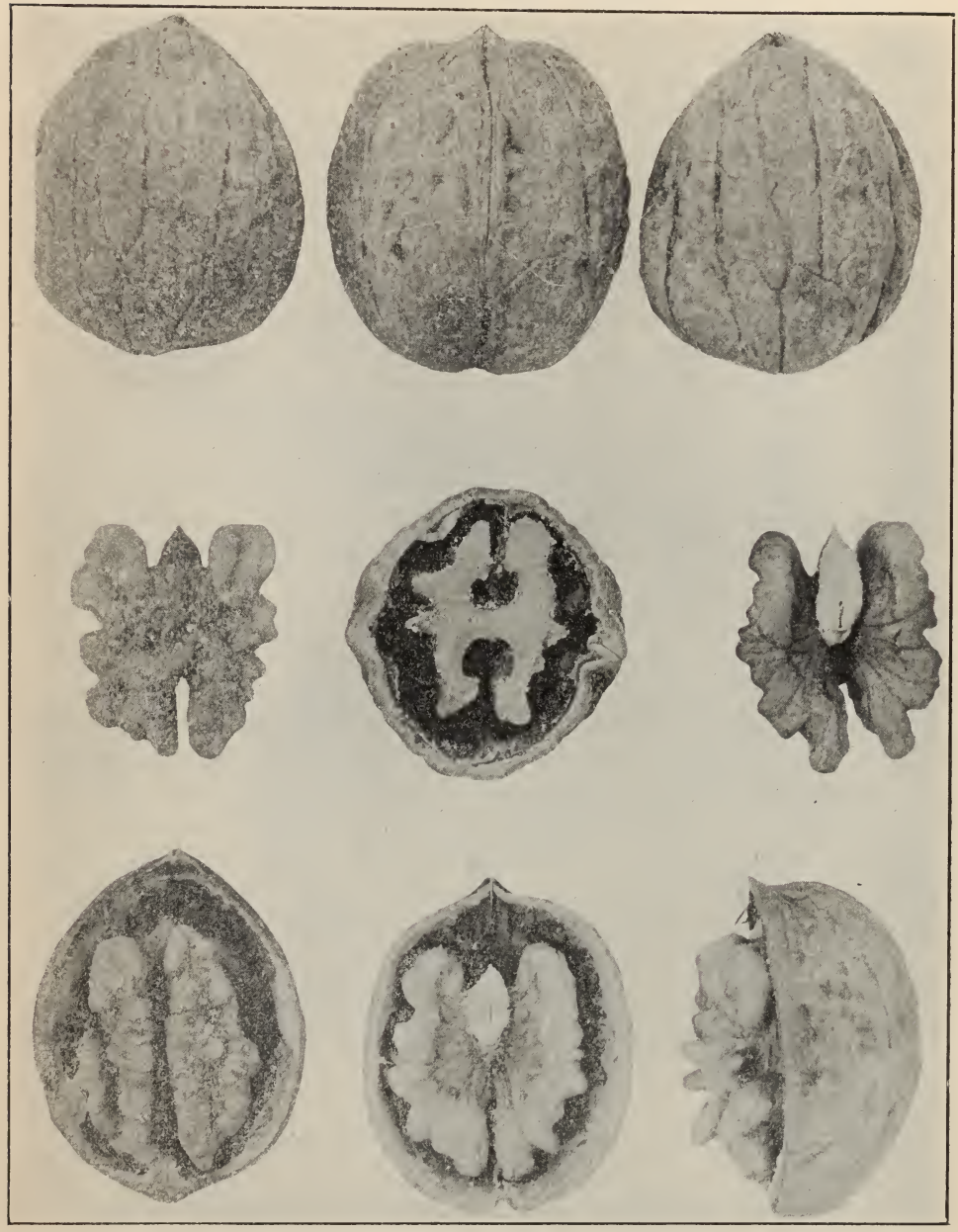

FIG. 72.—San José walnut, natural size.

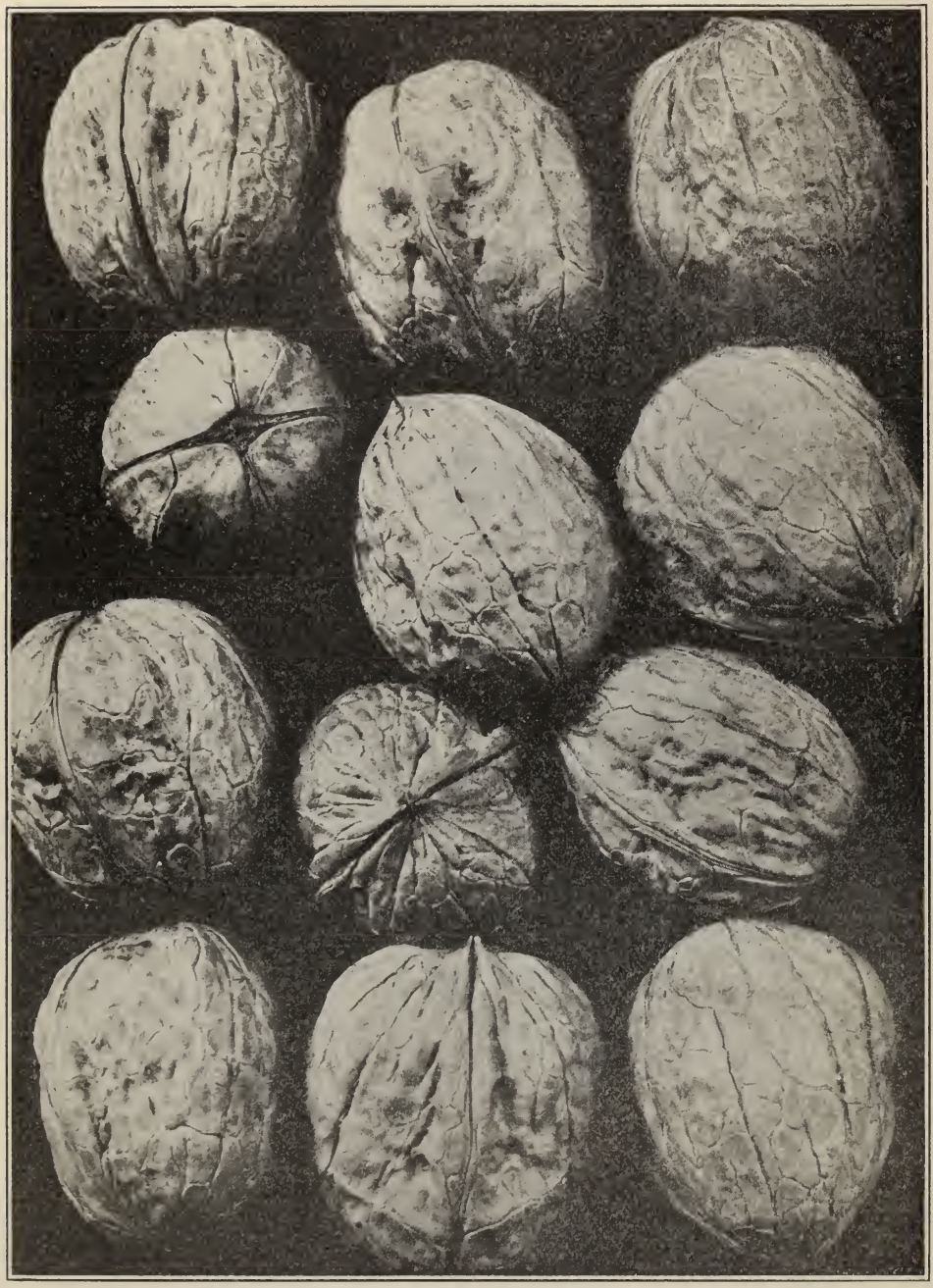

FIG. 73.—San José walnut, natural size.

Cracking Quality.

Nuts poorly sealed and very thin shelled, opening easily in the fingers.

Pellicle.

Light colored and attractive.

Meat.

Rather small in proportion to the shell and poorly developed.

Flavor.

Mild. Not pronounced.

TREE.

Foliation period.

Quite late, but earlier than Franquette.

Growth.

Slow and not particularly vigorous.

Foliage.

Rather sparse.

Harvest Season.

Medium.

Precocity.

Not well tested.

Production in Older Trees.

No information is available upon this point, except that obtained from Mr. Wiltz' place where the trees are of various ages and top-worked on black walnuts of various sizes. It is evident, however, that the variety is not a heavy bearer.

Susceptibility to Blight and Other Troubles.

The San José has not been widely tested in this respect, yet its behavior in respect to blight can probably be accurately estimated on account of the favorable conditions for disease in the locality where the variety originated. On Mr. Wiltz' place it appears to be decidedly free from blight, even compared with the Franquette which is later in coming out. We have little doubt but that the San José will prove decidedly free from blight in any portion of the State. As regards sunburn and other unfavorable climatic and soil influences, the variety is rather less promising on account of its slow growth and sparse foliage. The nuts are quite susceptible to perforation.

GENERAL REMARKS.

It is to be said to the credit of the San José variety that it is without doubt the most attractive and handsome of any walnut which has thus far been brought forward in California. Its large size, pleasing shape, and particularly its bright, yellowish-tan color, even when not bleached or even washed, makes it a most attractive nut and one which is invariably selected at first sight from all others, when in their natural

condition. For a few, extra handsome walnuts of average quality we have no variety at present equal to this. As a commercial nut, however, little more can be said in its favor. The tree is of slow growth and scanty foliage, a light producer, and the nuts are extremely light in proportion to their size, poorly sealed, susceptible to perforation or poorly formed shells, and with small, poorly developed meats.

OPINION OF AN EXPERT WALNUT BUYER.

Samples of all these varieties were submitted to the head buyer for one of the largest fancy grocery firms in California for his opinion as to their relative merits. This gentleman had already expressed himself in regard to the Placentia as follows: "The nut we have found most satisfactory is the Placentia. This variety combines good size, handsome appearance, good quality, good color and full meat." There would be little question of the all-round superiority of this variety over any other, for southern California at least, were it not for its blighting and poor sealing qualities. Fair samples of the following varieties were submitted to the expert, each under number rather than by name: 1, Eureka; 2, Franquette; 4, San José; 5, Concord; 6, Disher's Prolific; 7, Chase; 8, El Monte. His opinion follows: "Numbers 1, 2 and 8 are the finest nuts in the assortment, although it is very difficult to say which might be the best of the three for the reason that all possess some qualities which the others lack. For instance: No. 1 has a very handsome shell, a good fat kernel with exceptionally fine flavor, but the meats tend slightly toward a brown shade. No. 2 has a handsome shell but the kernel is not so fat as in No. 1, although the color of the meat is very good and the flavor excellent. No. 8 is not so handsome in appearance but the kernel is fat with good flavor but meat slightly brown. We believe, taking all things into consideration, that No. 1 has the most good points and if this variety bears well it would undoubtedly be a big success. No. 4 has the advantage of a thin shell, although this tends to perforation and we notice that the shell is not well filled, although the meat has a good appearance and flavor. No. 5 can hardly be compared with the others. This nut is more like the ordinary seedling nut which has been on the market for many years, although of a better quality than the average. No. 6 we find very similar to No. 1. This nut is very symmetrical in appearance, having a full, fat kernel but not quite so good a flavor as No. 1, while the meat is quite brown. No. 7 is good as far as size and quality of meat is concerned but in appearance not so good and the meat is too dark. Now to take all things into consideration, we would rate these nuts in the following way: Nos. 1, 2, 8, 6, 4, 7, 5." It should be understood that this gentleman passed simply on the quality of the nuts, without considering the producing or other qualities of the tree.

Size and weight of average specimens of principal walnut varieties. Weight in grams. Volume in cubic centimeters. Dimensions in inches.

Variety.	Weight.	Volume.	Dimensions.	Number per pound.	Per cent meat.	Specific gravity.
Chase	12	19	1.5 by 1.2 by 1.35	38	47	63
Concord	11	17.5	1.45 by 1.2 by 1.3	42	50	63
El Monte	14.5	22	1.7 by 1.4 by 1.4	32	50	60
Eureka	14.5	22	1.75 by 1.25 by 1.3	32	47	66
Franquette	12	20	1.75 by 1.25 by 1.3	38	46	60
Mayette*	13.5	21	1.6 by 1.25 by 1.25	34	50	63
Neff	14.5	21.5	1.7 by 1.3 by 1.4	32	47	67.5
Placentia	10.8	19	1.6 by 1.2 by 1.3	43	50+	57
Prolific	12	20	1.7 by 1.3 by 1.35	38	50+	60
San Jose	11.1	25	1.75 by 1.4 by 1.5	41	46	44.5
A. Bijou	25	50	2.25 by 1.5 by 2	18	35	50
Seedling No. 1	13	18	1.5 by 1.2 by 1.3	35	50	72
Seedling No. 2	11	18	1.5 by 1.2 by 1.3	41	55	60

*These samples may have been a little heavier than the average.

In the above table a very careful effort has been made to present average statistics of the varieties given. The reader should know, however, that this is an extremely difficult thing to do, since some of the varieties mentioned perform differently in one part of the State than in another, and, furthermore, nuts of the same variety vary widely on trees of different ages and under various conditions in the same locality. Again, especially in regard to weight and specific gravity, walnuts vary to a considerable extent from year to year. For absolutely average statistics, sample nuts would be necessary from various parts of the State from trees of various ages and on different types of soil and from the crops of several different seasons. It is impossible to obtain such samples at the present time in the case of practically all the varieties mentioned. The best that we can do is to present what in our judgment and as a result of our experience are fair, average figures for these varieties. We have endeavored particularly to bring out the comparative size and weight of the different varieties and believe that the figures given are fair and representative in this respect. The figures given were obtained as follows:

Weight.—Average weights were obtained by weighing large numbers of nuts, especially in the case of the more prominent varieties, and averaging these. In most cases nuts of more than one season's crop were included. Many weighings were also made by picking out individual nuts of average size and weighing these.

Volume.—The volume was obtained by partly filling a graduated cylinder with water, then immersing a given number of nuts and noting the height to which the column of water rose in the cylinder. The increase was then divided by the number of nuts, giving the average volume per nut in cubic centimeters. Here, again, large numbers of

nuts were measured in some cases and the results then averaged, while again an effort was made to pick out single nuts of average size and these were measured by the same method. It should be clearly understood in regard both to weight and volume that many nuts of the varieties mentioned are larger than these figures indicate and others are smaller. The figures are intended to represent the average size which the grower may expect to obtain from trees of these varieties over a series of years. It will be noted that size and weight are not always proportionate. San José, for instance, is about the same weight as Concord, but nearly 50 per cent larger.

Dimensions.—The dimensions were obtained by picking out nuts of average size and measuring the length of their three axes, first longitudinally, second through the shorter diameter and third at right angles to the last through the longer diameter.

Number per Pound.—This figure is intended to represent the average number of nuts per pound, as they would average in large quantities and without grading as to size.

Percentage Meat.—This figure represents the percentage of meat in the total weight of the nut. For instance, in the first variety given, Chase, there would be 47 pounds of meat and 53 pounds of shell in 100 pounds of nuts. The percentage of meat varies somewhat according to the degree of dryness of the nut. It is, therefore, impossible to give definite figures in this respect without some standard as to the dryness or moisture content. Nuts of the same variety may vary nearly 10 per cent in the amount of meat, according to the age and moisture content of the samples. After the first drying out of the nuts, however, following the harvest season and before they have become extremely dry, that is during the period from about December 15th to March 1st following the gathering of the nuts, they have a fairly constant weight when kept constantly dry at room temperature. This is the basis upon which the figures given are calculated. In each of the varieties given the percentage of meat sometimes runs higher and sometimes lower than the figures given, but these represent as nearly as possible average figures and we believe them to be accurate on a comparative basis between one variety and another. In weighing the meat and shell everything except the meat proper, that is particularly the septa or partitions between the divisions of the meat, is included with the shell.

It will be noted that in all the good varieties the percentage of meat lies between 45 and a little over 50. A variety which averages less than 45 per cent of meat in fairly dry nuts can hardly be considered worthy of consideration, while one which runs over 50 per cent is exceptional. The comparative percentage of meat in various varieties

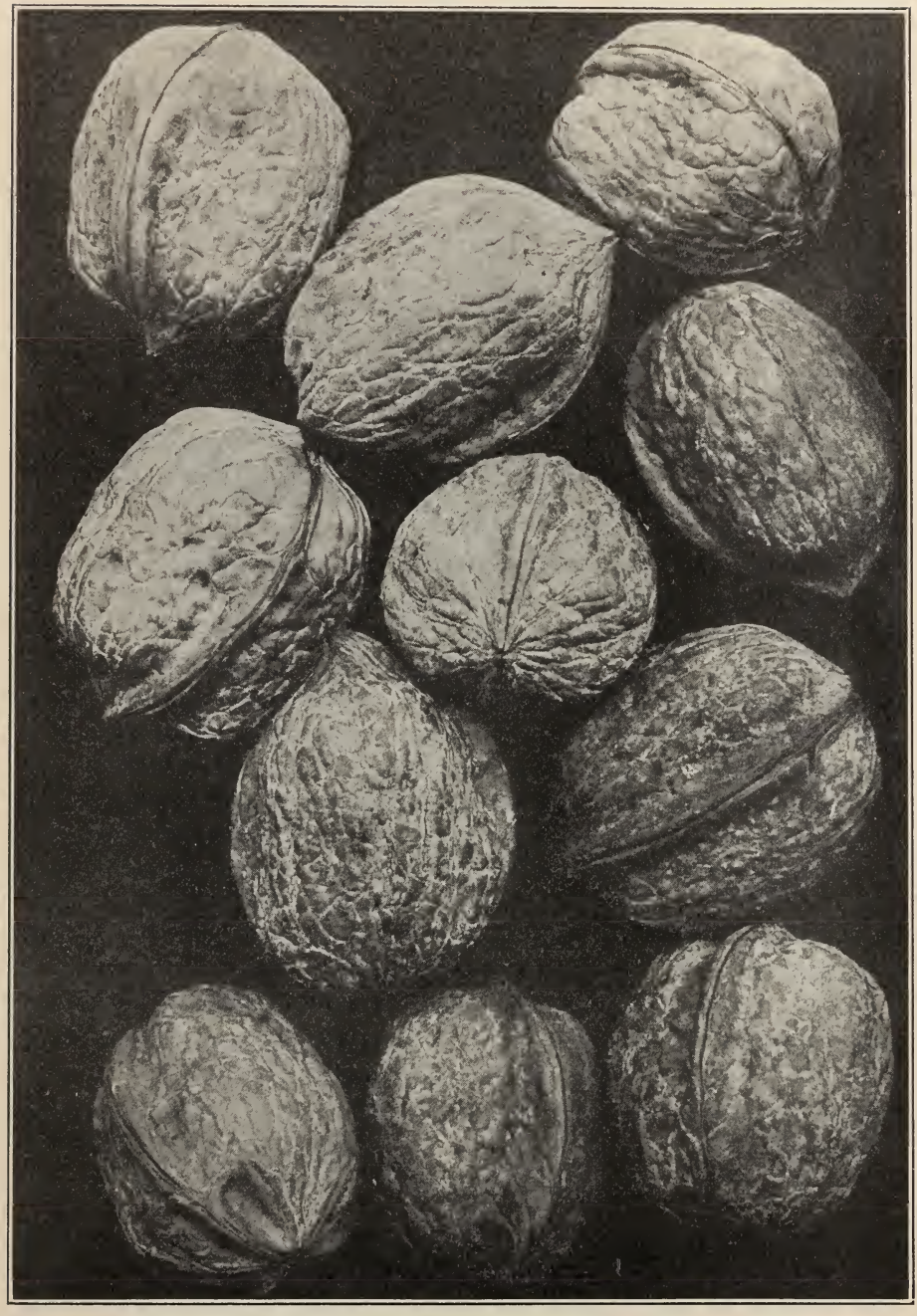

FIG. 74.—Neff walnut, natural size.

is influenced largely by the actual weight of the meat and shell; some varieties have a good meat, but also a heavy shell, while others may have no more or even less meat per nut, but a rather lighter shell, giving a higher percentage to a variety with less meat. Eureka and Neff, for instance, have 47 per cent meat against 50 per cent or more in Placentia. The two former varieties, however, average only 32 nuts to the pound, while with Placentia it takes an average of 43 to make a pound. In other words, in one average Eureka nut there is about 7 grams of meat, while in a Placentia nut there is only 5.4 grams, although the two nuts are of nearly equal size. Varieties like Eureka, Neff and El Monte have heavy shells, as well as heavy meats, and the same is true to a considerable extent with Chase, Franquette and Prolific. This condition is indicated by the high specific gravity of these varieties.

An instructive comparison is afforded by the figures given at the end of the table for Seedlings No. 1 and No. 2. These nuts average exactly the same size, both in volume and dimensions, but No. 1 is considerably heavier than No. 2, the number of nuts per pound being respectively 35 and 41. No. 1 is a nut of exceptional weight both of meat and shell, being of only medium size, yet one of the heaviest varieties in the list and at the same time having 50 per cent meat. Its specific gravity, 72, is the highest of any nut which we have tested, yet it is a soft shell and easily cracked in the fingers, though well sealed. Seedling No. 2, of the same size but lighter weight than No. 1, is a nut of exceptionally heavy meat (55 per cent) and very light, weak shell. On the latter account it is probably worthless, commercially, although of such exceptionally good meat.

Specific Gravity.—This figure is obtained by dividing the weight in grams by the volume in cubic centimeters. This represents the comparative weight of nuts of the same volume or size in the different varieties. For instance, with Chase and Placentia, which are practically of the same size, the weight of sacks of nuts of equal size would be as 63 to 57 in favor of Chase, while the number of nuts would be the same. Chase and Concord having the same specific gravity, 63, would weigh alike in sacks of the same size, but it would take more Concord than Chase nuts to fill the sack in the proportion of 19 to 17.5. Comparing the Eureka and San José, sacks of equal size would weigh 66 pounds of Eureka to every 44.5 pounds of San José, while at the same time there would be more Eureka nuts in the sack in the proportion of 25 to 22. Comparing Eureka with Franquette, the weights of sacks of equal size would be as 66 to 60, with the size of the nuts and, therefore, the number of nuts per sack about the same. The most desirable qualities are high specific gravity, fairly large size, small number per pound and high percentage of meat.

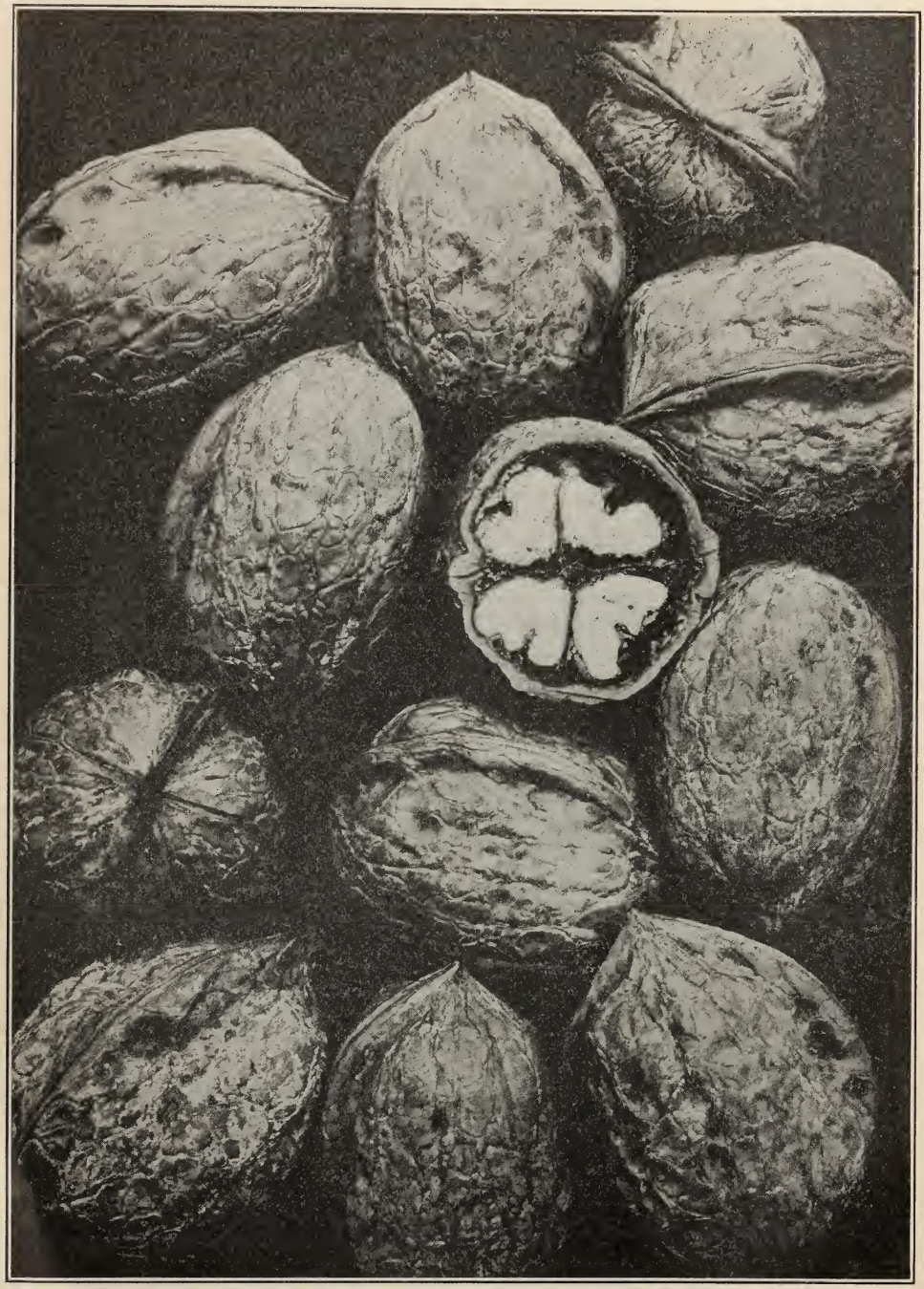

FIG. 75.—El Monte walnuts, natural size.

MISCELLANEOUS AND LESS PROMINENT VARIETIES.

The following is intended to complete as fully as possible a list and description of all the walnut varieties of any importance in California. Many of them are old French varieties which have not proven worthy of extensive commercial planting. Others are varieties not yet fully tested and most of the remainder have been discarded or never become prominent for various reasons. Bearing trees of most of the varieties in this list which are of any importance may be found in the State. At the California Nursery Company, Niles, there is a collection of most of the French and some other varieties; S. F. and F. A. Leib, of San José, have a large miscellaneous collection; Mr. Ely Hutchinson, of Concord, has a great many in bearing; Dr. W. W. Fitzgerald, of Stockton, has younger trees of many different kinds, and there are various other places in the north where, collectively, authentic specimens may be found of bearing trees of almost all the varieties which we mention. In the San Joaquin Valley the Fancher Creek Nursery Company has bearing trees of a number of varieties. In the south there are several of the French varieties on the old Experiment Station grounds near Pomona, and our Whittier Laboratory has a collection of practically every important variety growing either at Whittier or on the Pasadena City farm near Alhambra.

ACME.

Introduced by F. C. Willson, of Sunnyvale, California, in 1910. An extra large nut of Bijou origin. The nut is fairly smooth, rather elongated, larger at the apex than at the base and almost square in end view. The shell is quite heavy and fairly well filled with meat, which forms less than 40 per cent of the total weight. The variety is not apparently of any special value for general commercial purposes.

BARTHERA.

Introduced from France by Felix Gillet in 1871. Of no apparent value in California.

A BIJOU (Gant).

A French variety, noteworthy for the extremely large size of the nuts. Nuts very rough and poorly filled with meat and of no commercial value, save as a curiosity. Bearing trees are quite abundant in the State. Numerous Bijou seedlings are to be found in California, many of which have much smoother and better nuts than those of the parent. See "Acme," "Klondyke," and "Wonder."

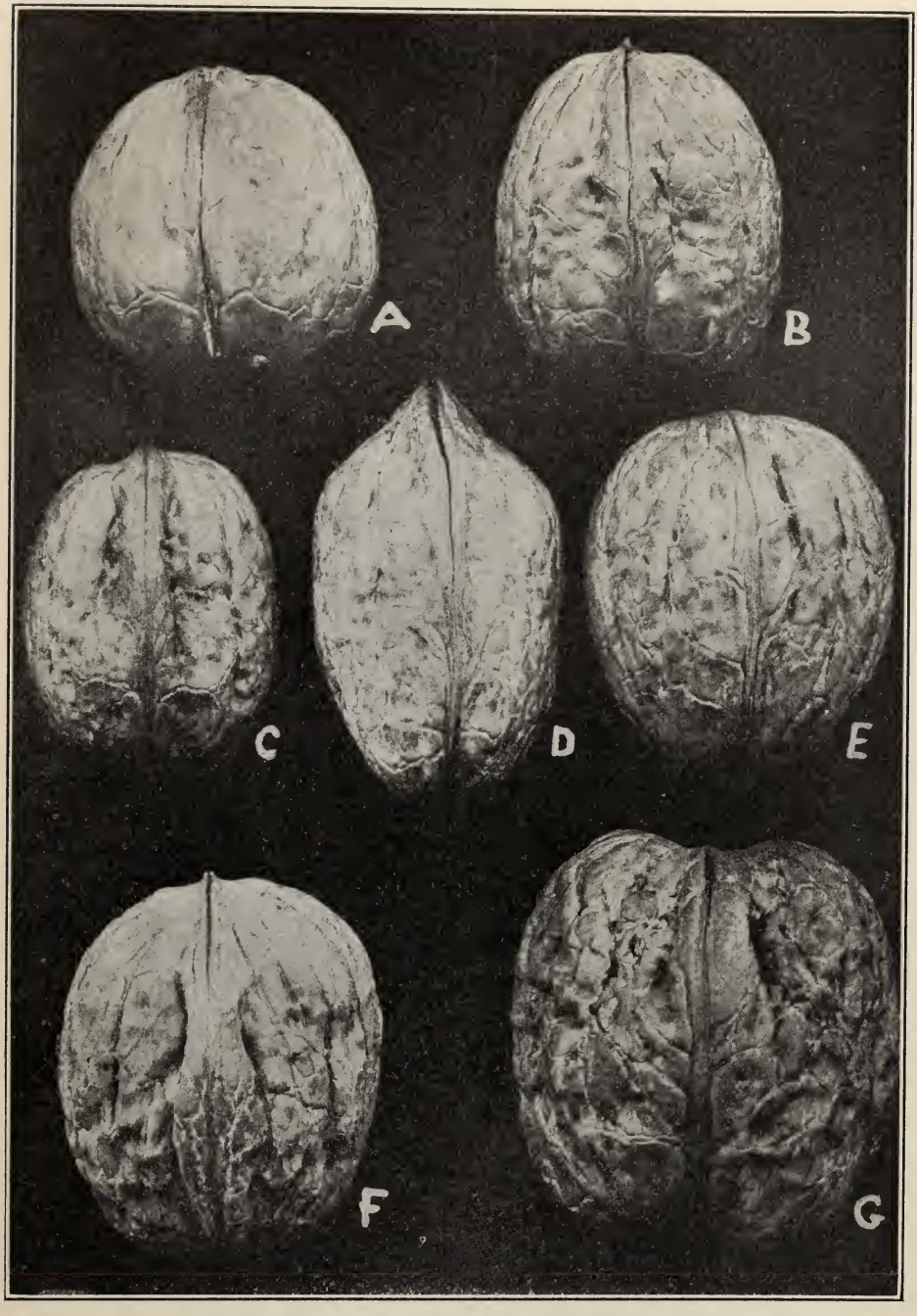

FIG. 76.—Various walnut varieties. A, Meylan; B, Mayette; C, Hale; D, Kaghazi; E, Seedling 501; F, Acme; G, Bijou. Natural size.

BISHOP.

We designate by this name a tree of some local fame, which stands on the Bishop, formerly the Colonel Hollister and still earlier the Denn Ranch, north of Goleta in Santa Barbara County. This tree is upwards of forty years old, and is the one remaining survivor of a former planting, now surrounded by a young orchard composed of its own seedlings. The tree is said to have been grown from a French nut and is called locally a Grenoble tree. It is a large, heavy-bearing tree, coming out decidedly late in the spring and practically free from blight. The nuts are not particularly attractive, though of average quality. The tree is not extremely late, but would probably come out about with Concord and Eureka if grown in the same locality. We doubt whether the nut is good enough to make the propagation of this tree desirable as a special variety, by grafting, although its good bearing qualities and freedom from blight are valuable characteristics. Many nuts from this tree have been planted by Mr. Robert Main, superintendent of the ranch, and in this way a local seedling strain has been developed, called the Main nut. There is a large orchard of these seedlings on the Bishop place surrounding the old tree, Mr. Main has a number of acres of them on his home place at Goleta, and there are others scattered about the neighborhood. Many of these are now old enough to bear considerable crops. It is remarkable that the seedlings of this comparatively late and blight-free tree have proved almost without exception to be early in coming out and particularly susceptible to blight. The tree has apparently been crossed by the surrounding Santa Barbara Soft Shell seedlings, or in any event almost all of its own seedlings come out decidedly early in the spring and blight very badly. Only one of the seedlings of this tree has yet been found which shows any promise of freedom from blight. This is the so-called Hicks tree, growing on Mr. William Hicks' place, between Santa Barbara and Goleta. This particular tree comes out early in the spring, but has thus far been quite free from blight, although surrounded by badly affected trees. It bears a nut of rather rough shape, but well filled, well sealed, light colored meat, good size and excellent flavor.

There is reason to hope that among the seedlings of the old Bishop tree there may yet be found some particularly good and blight-free individuals.

CHABERTE.

An old French variety which was introduced into California by Felix Gillet and considerably planted in the central and northern part of the State some years ago. The tree is a good producer of small nuts with plump, light colored meat. Not worthy of commercial planting in California.

CLUSTER.

One of Felix Gillet's varieties, introduced by him from France, and so named on account of the habit of producing nuts in large clusters. Not commercially important.

EL MONTE (El Monte Large).

A Santa Barbara Soft Shell seedling from the vicinity of El Monte, which has been propagated locally in southern California to some

FIG. 77.—Willson walnut, showing young tree next year after transplanting.

extent. The variety appears to be worthy of some little consideration although we have not much definite information concerning it. It is a large, quite rough, somewhat irregularly shaped nut, with pronounced sutural ridges and a decided beak or short, sharp point at the apex. The nuts are well sealed and filled with fairly light colored meat of pleasant flavor. The tree is a decidedly precocious bearer and thrifty grower.

It is early in foliation and harvest period, with probably no particular blight resistance, although definite information is lacking on this point. The large, well-filled nut and precocious bearing of the tree make this variety rather promising.

EUREKA No. 2.

Another of the Stone Kaghazi seedlings, standing just west of the original Eureka tree. Mr. Ware has six-year-old trees of this. It is a large, full-meated nut, a little rougher, softer-shelled and darker-meated than the Eureka.

FORD'S IMPROVED.

A selection from the Santa Barbara Soft Shell introduced by G. W. Ford, of Santa Ana. This variety appears to have been propagated largely by seedlings, and has now become almost lost, or at any rate it is no longer planted or propagated under the above name.

FORD'S EUREKA.

A Santa Barbara Soft Shell selection. Obsolete.

GRENOBLE.

A general name applied in California to walnuts of French origin. The name is supposed to indicate the Mayette type to some extent.

HALE.

A variety named and propagated to some extent by the Experiment Station, originating in a seedling tree in the orchard of Mr. William Hale, between Fullerton and Placentia. The variety was first mentioned by name in Bulletin 203 of the California Experiment Station, where it is figured on page 25. In this orchard there was formerly a considerable block of seedlings of some French variety, the trees of which varied widely in size, foliation period and character of the nuts. Among these one particular tree was selected as being of some promise for commercial planting. This tree was medium late in coming out, free from blight, large and thrifty, and a fairly heavy producer. A considerable amount of top-grafting with this variety was done on orchard trees in Los Angeles and Orange counties about 1907 and 1908. When thus propagated the variety proved to be fairly quick in coming into bearing, but of rather slow growth, making very stocky branches with considerable tendency toward the production of fruiting wood, but of rather short annual growth in length. The variety, like all others with a late foliation period in the spring, has not fully established its value in the south, but it may yet become of commercial importance in some portions of the State. The original tree, together

with the whole grove in which it stood, was cut down in 1911 to make way for oranges. The nut is medium large, decidedly elongated, with the apex as broad as the base. Considerably like Franquette (of which it may be a seedling) in form and size, but broader and less pointed at the apex. The nuts are strongly sealed but easily cracked, with a light-colored meat which is usually plump and well filled, with a particularly sweet and agreeable flavor. This is the sweetest nut of any variety which we have tested.

The value of this variety for commercial planting has not been thoroughly established, and we do not wish to recommend it for such purposes at present. It is possible, however, that it may prove worthy, especially in the north. The nut is quite similar to that of the Franquette, but slightly inferior to it in some respects. Judging from the original tree, however, it may prove a heavier and more precocious bearer than the Franquette. It is late enough in the spring to escape frost, decidedly free from blight and not objectionably late in the fall. Its foliation and harvest season is much the same as that of Concord and Eureka. We recommend this variety for limited trial, more particularly in the north.

HICKS (see Bishop).

HILDEBRAND (see Mayette).

KAGHAZI.

This is a name occasionally heard in California in connection with walnut varieties and is supposed to denote a variety native to Persia. In an article quoted from the *Gardners' Chronicle* in the *Rural Californian,* No. 9, Vol. 19, September, 1896, we find the following statement: "The Persian walnut is about a third or a half larger than the English walnut; of an elongated shape, with a very rich meat or kernel and a shell as thin as paper. It is not an unusual thing for a tree eight to twelve years old to bear 30,000 nuts or 1200 pounds." * * * "There are four kinds, the Kanate, the Wanter, the Denu and the Kaghazi, the last of which is the finest nut grown."

In Fuller's "Nut Culturist" we find the following: "*Kaghazi.*—This is supposed to be a variety of the Persian walnut of fair size with a very thin shell. The tree blooms very late in the spring, and for this reason is recommended for localities where there is danger from injuries by frost. The tree is said to be a very rapid grower and much more hardy than the general run of varieties of this species. We have been unable to learn its origin, but it has been planted to quite an extent in California and some of our eastern nurserymen are offering the seedling trees for sale, but whether they will possess the merits of the original or not must be determined by experience."

In Wickson's "California Fruits," we find the following: "*Kaghazi:* A variety called Kaghazi was grown and propagated for several years by the late James Shinn of Niles, who described it is follows: 'very much larger than the ordinary kinds and thinner shelled. The tree is late in putting out leaves and blossoms, and is therefore especially good for places that are in danger of late frosts.' "

It appears from the above quotations that the Kaghazi is an extra large, elongated, extremely thin-shelled nut, borne on a tree which comes out late in the spring. The variety would have no particular importance in California at the present time were it not for its apparent relation to the Eureka, the parent tree of which resembles very closely the above description of the Kaghazi. We have mentioned in describing the Eureka the fact that the original tree at Fullerton was found to be a seedling from a still older tree standing on the Meek homestead near Haywards. The particular tree which is the mother of the Eureka is the southernmost one of two which stand just east of the Meek residence. This old tree bears an unusually large, long, extremely thin-shelled nut, coinciding exactly with the description of the Kaghazi. In regard to the origin of this tree, Mr. H. W. Meek, now deceased, made the following statement: "All I know about these trees is that a neighbor of my father's gave him a few walnuts a number of years ago which he claimed he had received from the United States representative in Persia. My father planted the nuts, and the two trees which I have at present are the result. I do not know whether the walnut propagated by the late James Shinn has anything to do with the trees or variety which I have growing here. The Stones of Fullerton have some trees growing from the nuts from my trees here, but I have never heard how they turned out." In regard to the Shinn trees, Mr. J. C. Shinn states as follows: "The Persian walnuts we have possibly came from the same party referred to in a letter from Mr. Rixford which I enclose, though my memory is that they came from some one in Illinois who had tried trees raised from nuts direct from Persia and found them too tender. They were bought about the year mentioned by Mr. Rixford. The late James Shinn bought, as he understood, the whole stock of the party who brought the nuts over. The party sent a few nuts as a sample and they were a very large, thin-shelled nut. There had been some report in a United States agricultural report about that time that had aroused his interest. We sold many seedling trees, much seed for planting, and later quite a number of grafted trees of the Persian or Kaghazi walnut. There must be thousands of bearing trees in the State from those we sold." The letter from Mr. Rixford, referred to, states as follows: "In September, 1873, Mr. Finch of Alameda ordered from Rosse & Grant, Topeka, Kansas, fifty Persian or Kaghazi walnut trees.

The stock being short, he secured but thirty-six. Of these he sold to Mr. Latham ten at ten dollars each, to Mr. Selby two, to J. D. Roberts four, and to Mr. Meek of Alameda twelve. Rosse & Grant claim to have obtained the seed from the Cashmere Valley, Persia.''* Further inquiry of Mr. Shinn in regard to the parties mentioned in this letter brought out further information in regard to the extensive scale upon which Kaghazi trees, mostly seedlings, were sold by his father during the eighties and nineties.

It is evident from what we have said that this is a fairly distinct variety, and that, if Mr. H. W. Meek's memory was correct, it was introduced independently into California by his father, William Meek, and the late James Shinn. Trees are still to be found here and there about the State which are evidently of this sort. There are several long rows of the seedlings on the old Meek place, some extending from the residence toward the town of Haywards and others along various other roads. There are a number of trees of similar nature in Contra Costa, and in that locality one particular type of this sort has been quite extensively propagated by grafting under the name of Persian. A large number of the older, top-grafted walnut trees in the San Ramon and other valleys in the Mount Diablo country are of this so-called Persian variety. There is quite a number of trees of Kaghazi type in the vicinity of the Shinn place at Niles and also about the Niles High School and vicinity. Near Goleta there is a considerable orchard of similar seedlings on the ranch of the Goleta Walnut Company. These trees vary quite widely in many respects, but as a whole they are marked by a late and irregular coming out in the spring and the peculiar appearance of the bark on the trunk, which is cracked or grooved characteristically in an up and down direction. A great many of the trees bear nuts which are extremely thin-shelled and poorly sealed, and some of them are quite desirable except for this defect. Some of them are nuts of the highest eating quality, of fine shape and beautiful, light-colored shell and meat, but with shells which open at the slightest pressure of the fingers. It is remarkable that of the many hundreds and thousands of seedlings of the Kaghazi type which have been brought into bearing in California only one, the Eureka, has shown exceptional worth. It seems probable that this is the result of a cross of the original Meek Kaghazi tree with some hard-shelled English walnut in the vicinity, as the shell of the Eureka is particularly hard, strong, and well sealed.

*The Kashmir Valley lies just northwest of India rather than in Persia, and is, we are credibly informed, the home of the Kaghazi walnut.

KEESLING.

A rather promising walnut has recently been sent us by Mr. H. G. Keesling, of San José. This is the variety called Seedling No. 2 in the table on page 300. The nut is particularly well filled, of good quality, and has the highest specific gravity of any which we have mentioned. We know nothing of the bearing quality or other characteristics of the tree.

KLONDYKE.

A name applied in southern California to very large walnuts of the Bijou type. The name seems first to have been given to a particular tree of this sort in the vicinity of Santa Ana.

LACINIATED.

A variety introduced by Felix Gillet, having finely cut or divided leaves, giving an ornamental effect. Not commercially important, although the tree is a good bearer of very good nuts. The tree is decidedly ornamental on account of its graceful foliage. Specimen tree at California Nursery Company, Niles.

LANE.

This is a local Santa Barbara variety which has been propagated by grafting to a slight extent in that vicinity. The variety receives its name from Mr. Miles P. Lane who has a young grafted tree, the scions having been obtained from Mr. W. H. Johnson, on whose ranch the original tree is growing. The latter is a Santa Barbara County seedling of unknown parentage. The variety is decidedly early in coming out in the spring, but yet, as thus far shown, it is entirely free from blight, although immediately surrounded by badly blighted trees in the same orchard. The nut is of light color and heavy, well flavored, light colored meat. The tree appears to be a prolific and precocious bearer. It has much promise of making an unusually good variety, save for the one fact that the nuts are very poorly sealed, breaking open at the slightest pressure. For this reason there is some doubt whether this can be considered a good commercial nut. It appears to have real resistance to the blight organism, inasmuch as the trees come out so early and still are free from the disease, though abundantly exposed. This variety is the Seedling No. 1 mentioned in the table on page 300.

MAIN (see Bishop).

MAYETTE.

This is an old French variety and is considered the choicest of the French kinds.

The Mayette in California varies quite widely in character and leads one to suppose that either there has been considerable mixing in the

introduction of this variety or else the Mayette in France represents a general type propagated largely by seedlings, like our Santa Barbara Soft Shell, rather than a distinct variety propagated exclusively by budding or grafting. Most of the so-called Mayettes in California have a general resemblance to one another and appear to be seedlings or derivatives of the same general type.

The variety is characterized by the shape of the nut. In the true Mayette type the base of the nut is decidedly flat and square-cut, so that the nut can easily be set upon the basal end without falling over. The nut rounds broadly to a point at the other end, giving it a sort of flatiron shape. In good Mayettes the meat is plump and well developed, averaging close to 50 per cent of the total weight, and very light colored and attractive. In flavor there is considerable variation in various Mayette types found in this State, but the best of these are excellent in this respect. The shell is thin but strong and well sealed. The Mayette is a tree of comparatively late coming-out in the spring, though usually somewhat earlier than the Franquette. It is decidedly later than the southern California seedling trees. In most cases the time of maturity in the fall is fairly early as compared with late varieties, though somewhat later than ordinary California seedlings. Of the so-called Mayettes to be found in California some have no resemblance whatever to this variety and need not be considered. Among those which have the true flatiron shape Mayette type of nut, with a flat base upon which the nut can easily be set up, there is still considerable variation. Of the older trees which are attributed to Felix Gillet, many are evidently seedlings and thus vary to a greater or less extent. No especially desirable true Mayette type has thus far appeared among the older Gillet trees. Probably the best Mayettes in the State are to be found on S. F. Leib's place at San José, these being trees grown from a large lot of scions which Judge Leib imported from France about five years ago. In this importation an effort was made to obtain the best type of the true French Mayette, but among the trees grown from these scions wide variations have appeared. Some of these trees, however, represent, as we have said, what appears to be the best Mayette type in the State. These are large, smooth, light colored, attractive looking nuts of typical shape. They are well filled with very light colored meat of excellent flavor. The growth appears to be more vigorous than that of the Franquette. It is not improbable that had a Mayette type as good as this been introduced and planted on a large scale a number of years ago, it might have proved as good or even better than the Franquette. Under existing circumstances, however, it is not possible to judge the variety critically as to production and other important considerations. Mr. Ely Hutchinson, at Concord, has a number of trees of a Gillet Mayette

with which he has been quite well satisfied and which he is inclined to put ahead of the Franquette for his locality at least. On the former Kerr ranch near Elk Grove, now belonging to a Mr. Powell, there is a valuable collection of fairly old, producing walnut trees top-grafted on California blacks, which originated from scions which Mr. Kerr imported from France a number of years ago. There are trees here of the Parisienne, Franquette and some other varieties, and also a considerable number of Mayettes of a very good type. This Mayette has received more or less prominence through Tribble Brothers of Elk Grove, who have propagated it to a considerable extent. There is some variation between the various Mayette trees on the place, but this may be largely accounted for by differences in soil and moisture conditions where the various trees stand. This Tribble Mayette is the best tested of any in California, and appears to have no little merit. The trees are growing in a region with a very hot, sunny, summer climate, and various specimens may be seen about Elk Grove which are growing over shallow hardpan and entirely without irrigation. Nevertheless the nuts are uniformly white meated, with no discoloration by the sun, and the trees are thrifty growers and fairly heavy producers. Another tree, apparently a Mayette seedling, is the so-called Hildebrand tree which stands on the ranch of this name a few miles above Linden and not far below Milton in Calaveras County on the south fork of the Calaveras River. It is said that this tree came from a nut distributed by Mr. J. P. Rixford, then of the San Francisco *Bulletin*, in 1878. In an article in the *Pacific Rural Press* of April 17, 1909, the suggestion is made that this tree is probably of the Kaghazi variety. Such is probably not the case, however, as the character of the nut gives every reason to suppose that the tree is a Mayette seedling. The tree is unusually large, being 70 feet high with a spread of about 60 feet, and is in a perfectly thrifty condition with no sign of die-back or deterioration. During recent years the tree is said to have produced from 300 to 500 pounds of nuts per year. The nut is of fairly good Mayette type, but not of exceptional quality. It is possibly of some promise on account of its freedom from sunburn, as the tree is growing in a very hot region. It is also unusually thrifty, although this is partly accounted for by the fact that the tree stands alone in excellent soil. We have two Mayette trees on our own grounds which were imported from France as grafted trees by Felix Gillet in 1907. These trees are just coming into bearing and have produced nuts which appear to be of an excellent Mayette type.

In general, then, we may say of the Mayette that it is very much mixed in this State, and outside of one or two special strains, the grower has very little assurance of what he is getting in buying Mayette trees. The best type of the variety is represented by a nut of very high quality,

and it is possible that such a Mayette may become of increased importance in the future in the northern part of the State, even outranking the Franquette. It does not appear probable, however, that any of our Mayettes are especially heavy bearers in the south, and it is doubtful whether any variety as late as this will ever become of great importance or value there.

MAYETTE BLANC.

This name is supposed to indicate the true Mayette.

MAYETTE ROUGE.

A variety supposed to be a variation of the Mayette, with a reddish colored shell. Not commercially important.

MESANGE.

A French variety described as bearing a nut with a very thin shell. The name is derived from a little lark which pecks the kernels through the thin, tender shell. Not important.

MEYLAN.

A French variety having the reputation of being the finest of all walnuts. The nut is somewhat of the Mayette type, having a broad, rather flattened base, rounding to a very broad point at the other end. The surface is smooth, having a light, attractive color. Meat very light colored and fairly well filled. Good flavor. This variety in California is probably not a sufficiently heavy bearer to warrant its commercial planting, although the nut is beautiful in appearance and of high quality.

MONSTREUSE.

A French variety of which there is a tree in bearing at the California Nursery Company, Niles. Never distributed in California to any extent. The nut is rather large, rounded, with smooth surface and of fine appearance. Probably not commercial in California, but a nut of exceptionally good appearance.

NEFF (Neff's Prolific.)

A tree selected from his orchard for propagation by Mr. J. B. Neff, of Anaheim. The original tree stands in Mr. Neff's old orchard and is presumably a Santa Barbara Soft Shell seedling. Mr. Neff selected this tree on account of the fact that it was averaging about 200 pounds of nuts annually, which production far exceeded that of any other tree in its vicinity. Mr. Neff therefore cut back many of his poorest producing trees and grafted them over with scions from this heavy bearing tree.

The original tree is decidedly free from blight, although not totally immune to the disease. The nut is of good size, well sealed, excep-

tionally heavy and well filled with light-colored meat. The flavor of the nut is good. In form the nuts are rather rough and irregularly shaped, this being the greatest defect of an otherwise very promising variety. The shell is heavy, giving the nuts good weight in the sack. The variety has not been propagated to any extent, save in top-working old trees, so nothing can be said as to its behavior as a young tree. For a heavy bearing, heavy weighing variety for the ordinary commercial trade, the variety has considerable promise. For a fancy, attractive nut, it is not so good, on account of its rough, irregular shape.

PAPER SHELL.

This is a general name applied to walnuts with exceptionally thin shells. The name is also applied to a certain type of tree which originated with Joseph Sexton, of Goleta, along with the original trees of the Santa Barbara Soft Shell type. These paper shells were so called from the thinness of the shell, but the name as applied in the Santa Barbara section refers to a certain type of tree, some of which have real paper shell nuts, while others do not. These trees are of a characteristic small size, round dense top, and bear a small, usually roundish, smooth, light colored nut. Many of them resemble very closely the Chaberte variety. These typical paper shell trees are decidedly susceptible to blight, and on account of this quality and the small size of the nuts and trees the type is not considered desirable.

PARISIENNE.

A French variety introduced by Gillet and others.

This is one of the best of the French varieties and might become commercially important in California except for its light production. The nut is rather long and pointed, somewhat resembling the Franquette, but broader in the center. The shell and meat are both light colored; the nut fairly well filled and of good flavor. Very late in coming out in the spring.

PERSIAN (see Kaghazi).

POWELL (see Mayette).

PRIDE OF VENTURA.

A Santa Barbara Soft Shell seedling tree selected by E. O. Tucker of Ventura, California.

This is said to be a very precocious and heavy bearer, but with no special immunity to blight. The nut is decidedly large, rather round and somewhat rough. This variety has been propagated and planted to some extent in the vicinity of Ventura.

PRŒPARTURIENS.

A French variety introduced by Gillet, which was planted quite extensively in central and northern California some years ago. The nut is rather small and the variety can no longer be considered worthy of commercial planting.

SANTA BARBARA SOFT SHELL.

This is the prevailing type of seedling walnut of southern California, originated by Joseph Sexton. Its history has been described at length on page 173. The trees and the nuts which they bear vary to a considerable extent among themselves, but yet are mostly of the same general type. The nuts are usually of good size, easily cracked in the fingers, and of excellent flavor and quality. The trees come out fairly early in the spring and usually produce an abundance of pollen. This type is particularly well adapted to southern California, except for its susceptibility to walnut blight and the variation in trees produced by seedling propagation through several generations. Some of the varieties, like Placentia Perfection, Discher's Prolific, Neff, El Monte, Pride of Ventura and others, obtained by selecting individual trees of this type, are most excellent in every way except for the susceptibility to blight or individual minor defects. An ideal variety may yet be found among the many hundreds of thousands of trees of this type now growing in southern California.

SANTA ROSA.

A variety first introduced by Luther Burbank and considered at one time of great promise on account of its productiveness. The nut is rather small, however, and has proven to be one of the most susceptible of all varieties to the blight. Consequently, its further planting cannot be considered advisable. The Payne tree at San José is top-worked with this variety and bears immense crops of nuts.

SEEDLING (see Santa Barbara Soft Shell).

SEROTINA.

A French variety introduced by Gillet. Of no commercial importance.

SOFT SHELL (see Santa Barbara Soft Shell).

TREYVE.

A French variety of the Mayette type introduced by Gillet. But very little planted in California. This is a beautiful nut, especially on account of its almost pure white meat. Mr. Ely Hutchinson, of Concord, has the variety in bearing. Probably not commercially important on account of poor production.

TRIBBLE (see Mayette).

VOUREY.

A very good French variety introduced by Gillet, but, like most of the other French varieties, a poor producer in California.

WAGNER.

A Royal hybrid tree which has been progagated, advertised and sold by Mr. J. B. Wagner, of Pasadena. The tree was recommended for shade, wood, and timber. The original appears to have been a cross between the southern California black walnut and an eastern or possibly Royal black. It is a thrifty, vigorous type, like other good Royals.

WILLSON (Willson's Wonder).

A Bijou derivative propagated by F. C. Willson, of Sunnyvale. The nuts are very large, but much smoother and better filled than those of the Bijou. The variety is claimed to be extremely immune to blight in the locality of its origin. It is also particularly claimed for the Willson that it is extremely precocious, bearing nuts while still in the nursery and coming immediately into bearing after planting in the orchard. Figure 77 shows a young tree of this variety, the picture being taken, it is said, the next year after the tree was planted in its present location. The variety has not been widely enough tested to warrant any strong statement either for or against it. Its precocity in bearing appears to be well established, and being quite late in coming out in the spring, its blight immunity may be counted upon to a considerable extent. As to the desirability of so large a nut as this for general commercial planting, there is some difference of opinion. Some consider the nut too large except for a novelty; Mr. Willson claims that the quality of the nut is so excellent that its large size is an advantage rather than otherwise. It may certainly be said that the Willson appears to be much the best of any of these extra large nuts. The flavor is mild and sweet. The nut is decidedly smooth and symmetrical for one so large, being somewhat broader at the apex than at the base and nearly square in end view. The largest nuts on some trees measure nearly 2 by 3 inches, while on older trees an average size of perhaps $1\frac{1}{2}$ by 2 inches may be expected.

We name this variety "Willson" rather than "Wonder" with the approval of the originator.

DISEASES AFFECTING THE WALNUT.

WALNUT BLIGHT OR BACTERIOSIS.

This is by far the most important trouble affecting the walnut in California. So serious has been this disease that the loss of a large portion of the crop has in some years been charged to this source; legislatures have made special appropriations for its investigation, and the growers have offered a large reward for a practical remedy. The ravages attributed to blight were the occasion of the investigations described in this bulletin and the prevalence of the disease has resulted in changing the whole aspect of walnut culture in California within a period of comparatively few years. The following account has been prepared mainly by Mr. C. O. Smith, who has carried out most of this portion of the work.

The bacterial diseases of plants are more and more engaging the attention of plant pathologists. Most of these have only within recent years been well understood. At present, however, there are a number of very definite plant troubles due directly to these micro-organisms living in plant tissues. One of the most important of this class of plant troubles is the bacterial blight of the Persian or English walnut.

Bacterial diseases of plants are, as a rule, much more difficult to control than those caused by fungi, and do not readily yield to treatment by spraying. Our experiments in spraying will be described in full at another point in this article, but the unsatisfactory results we secured in checking the development and spread of the disease show quite conclusively that the solution of this problem lies along other lines. The solution of the trouble is quite as much a horticultural as a phytopathological problem, involving as it does the growing of varieties that show a certain amount of resistance or in which the nuts escape the blight because of their late period of blooming in the spring after the period of blight infection is largely past. The walnut industry is just now in a state of transition from the seedling orchard to one containing only the best and most productive, non-blighting varieties. A number of these have been quite thoroughly studied by the Laboratory of Plant Pathology in southern California and some of our observations are given in detail in another part of this bulletin.

Host.—The natural occurrence of bacteriosis or walnut blight is probably confined to the English walnut, or its hybrids with the blacks. Blighted nuts have been collected from a Paradox walnut tree (a hybrid of English and California black) and the organism has also been isolated from the leaves of Paradox seedlings growing in the Experi-

ment Station nursery. The disease has never been found on the straight California black or on Royal hybrids, although it can be produced artificially by puncture inoculation on various species of *Juglans*. In one instance a case of blight infection was observed in the nursery on the leaves of California black seedlings near a badly diseased branch, caused by artificial puncture inoculations. It is probable that these leaves were infected from the disease on the branches.

Popular Name of Disease.—Newton B. Pierce first described this disease as walnut bacteriosis, but locally it is also known as walnut blight. In this paper, however, the more suggestive term Bacteriosis will be used for the most part.

Geographical Distribution.—It is not definitely known just how widely spread this disease may be. In the United States it is found more or less scattered over California, some localities being more severely infected than others, due either to climatic conditions or to the disease not yet having obtained a foothold. California has had the disease for a quarter of a century, and now it is beginning to show itself in Oregon.[1] The disease has also been reported from Texas,[2] and is said there to attack nearly every year all the native nuts of the walnut family. This Texas trouble has not yet been, with certainty, identified as the same disease as the walnut bacteriosis in California. Diseased walnut leaves have been received from at least one point about midway down the Pacific coast of Mexico. From this diseased material typical walnut blight cultures were grown. The walnut trees were, however, imported from California. This disease will probably appear wherever the English walnut can be commercially grown in the United States, and the only reason that it is of no economic importance in the Southern and Eastern States is because the walnut industry has not yet been developed there. In foreign countries the disease has been reported from New Zealand.* California walnut growers who have visited France report having seen our trouble on French walnut trees. Too much reliance cannot, however, be placed on these observations because of a fungus disease (*Marsonia juglandis*) that produces quite a similar appearance to that of our walnut blight. (See description of *Marsonia juglandis,* page 325. The testimony of these growers is, however, strengthened by certain observations of our own. In 1907 walnut scions were imported from France, and among these were several that had what appeared to be typical walnut blight lesions. Cultures

[1]C. I. Lewis, Oregon Experiment Station, Bul. No. 92, p. 19.

[2]G. E. Schattenberg, Texas Department of Agriculture, Bul. No. 2, pp. 42-43.

*W. A. Boucher, New Zealand Department of Agriculture, Report 1900, pp. 334-335. T. W. Kink, New Zealand Department of Agriculture, Report 1907, p. 167.

were made from these diseased scions, but from the limited material at hand no true walnut blight organism was isolated. These scions were grafted into black walnut trees and in the new growth from some of the scions typical walnut bacteriosis appeared close to the old wood of the scion, although there was no walnut blight in the vicinity, local scions did not develop the disease, and on the shoots from the French scions blight developed only close down to the original imported wood. While the evidence seems to indicate that this disease may have been introduced from France, we have found no report of its occurrence in that country in available literature. It may, however, be confused with their *Marsonia,* and really occur there to a limited extent.

History of Disease in California.—The disease has been known for a considerable time in California. The first published account which we have found occurs in the report of the Secretary of Agriculture for 1893.* At that time the true cause of the trouble had not been demonstrated, although the presence of a bacterial organism had been found constantly associated with the disease, and pure cultures of an organism had been made by Professor Newton B. Pierce, who was then in charge of the Pacific Coast Laboratory of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture.

Growers affirm that the trouble had been known for several years before this time. According to local accounts, it appears that the disease first became noticeable in the principal walnut districts of Los Angeles County about 1891. The disease occurred then in a very limited way and seems to have attracted attention, not on account of the extent of its ravages, but simply from the fact that it was something new. Growers who observed the blight at that time claim that its occurrence coincided with the distribution of trees from a certain nursery in Orange County, the proprietor of which nursery imported walnut trees from France a few years previous. Whether or no these statements are correct, it appears to be undoubtedly true that the blight was first noticed in Los Angeles County about 1891, that it came thence from Orange County, and that the disease then spread northward to Ventura and Santa Barbara counties until at present it occurs in practically all parts of the State where walnut trees exist.

Walnut bacteriosis is by far the most prevalent in the older walnut sections. Some differences as to amount and severity can, of course, be noted in different places, due either to different climatic conditions or to the fact that the disease has not yet been introduced. The newer groves that are now being grown in central and northern California are

*Report of Secretary of Agriculture, Division of Vegetable Pathology, 1893, p. 273.

at present only troubled with this disease to a limited extent. In northern California and Oregon there are few commercial bearing groves at the present time. This disease shows the greatest variation in the amount of infection from year to year, and while it may seem to be scattered throughout a grove, yet there are trees here and there that are almost free from attack. Some years there is almost no blight or only a small amount of early infection. There is less infection in a bright spring that is free from fogs and cloudy days.

The disease is now distributed all over California, being often found even upon isolated walnut trees situated a long distance from any others of the same kind. It has no doubt been generally disseminated through nursery stock, which is often infected, and may also be carried through the air. Localities with much foggy or moist weather during the spring show the most severe attacks of blight, but in places where the crop is largely grown, as in the southern part of the State, the disease becomes more conspicuous, although it is really more prevalent and virulent in some other parts of the State where the walnut crop is less important. The occurrence of the disease varies everywhere in direct proportion to the amount of atmospheric moisture during the spring and early summer months, from the time the trees start into growth until the nuts are well advanced in development. The amount of blight likely to occur in a given locality or given season can be closely estimated on this basis, as the connection between the occurrence of the disease and the amount of atmospheric moisture is well established. Localities with much spring and summer fog may expect a considerable development of walnut blight, while those where such weather does not prevail may safely count upon being reasonably free from this trouble, even though it be frequently introduced. The same rule applies as to the occurrence of the disease in different seasons.

Losses from Blight.—The amount of loss actually caused by this disease has been every year very large for the past ten years or more, but has varied considerably from year to year. It is also true that much has been attributed to blight which in reality had nothing to do with this disease, such as the effects of drouth, frost and other unfavorable climatic or soil conditions. At the same time the losses directly attributable to blight have been extremely large. One significant fact in this connection is that while the walnut acreage in southern California has multiplied many times during the past decade, the total walnut crop of the State has increased very little during this time. In fact, the crop has been actually much less during several years of this period than it was in some of the best years of the preceding decade. This loss or failure of the crop to increase has not been entirely attributable to blight, yet it has certainly been due to the disease much more than to

any other one factor. In the year 1903, one of the first bad blight years, the total crop of the State fell off to only a little more than one half of that of the previous year. It is probably conservative to state that in the seedling groves of southern California an average loss of at least 50 per cent of the crop which would otherwise have been harvested has been caused by the blight during the past ten years. Many individual trees may be seen some years which show a loss of practically all the crop from blight. This disease affects the quantity and, to some extent, the quality of the crop much more than it does the growth of the tree, being of less importance in that respect than pear blight, for instance, and many other plant diseases. While the leaves and young shoots become affected to some extent, as we shall describe later, this injury in otherwise thrifty trees is soon overcome during seasons when the disease is less prevalent, and is not usually a serious matter. In occasional instances, especially on light, dry soils where the trees are at best none too thrifty, sufficient twig infection sometimes occurs to actually stunt and dwarf the trees to a considerable extent by a continual killing back of the young twigs. Damage is also done in such cases by the loss of the fruit spurs which should produce the catkins and nut-bearing shoots the following year.

It should be clearly understood that walnut blight is not conspicuously a die-back disease of the tree, but is more especially a source of loss in the amount of the crop, varying widely in prevalence from year to year, and not, in the majority of instances, seriously affecting the life or growth of the tree.

Earlier Studies.—Reference has already been made to the work done by Pierce. He first isolated the organism and printed quite a full and accurate, technical description[1] of the disease and its physiological and pathological characteristics. He also published several more popular accounts of the trouble.[2] Various experiments in spraying were made by him in trying to control the trouble by such means, the results of which will be more fully discussed under another heading. He also observed that certain walnut trees seem to possess a certain immunity to the disease, but did not indicate that the time of blooming had anything to do with the amount of blight that developed.

In 1905 the California legislature made a special appropriation to the Experiment Station for carrying on an investigation of this disease, and Mr. A. M. West was appointed to work on the problem. He isolated and studied the organism and confirmed in most respects the work previously done by Pierce.

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[1] *Botanical Gazette,* 1901, 31, p. 273.

[2] *Pacific Rural Press,* 1896, 57, No. 25, p. 387.
California Fruit Grower, 1896, 19, Nos. 13, p. 243; 16, p. 316.

The work here recorded covers the results of previous investigators, verifying them in most cases, while some new data has also been added.

Cause of Disease.—The disease thus far discussed has been conclusively proven to be produced by a species of bacteria growing in the diseased parts, and hence is very properly referred to as *Bacteriosis.* A microscopic examination of diseased tissue shows countless numbers of these small, rod-shaped organisms to be present. By employing bacteriological methods pure cultures of these germs were obtained and then these pure cultures were used in making artificial inoculations into healthy nuts and shoots, thus again producing the typical disease. The organism has been isolated many times, and no difficulty has been experienced in always producing the disease by inoculation from culture if the tissue was in an active growing condition.

The walnut blight organism belongs to what are called the bacteria; low forms of plant life that are extremely small in size and increase rapidly in number by elongation and division or fission. When grown in artificial cultures in mass they have a shiny yellow appearance.

Confusion with Marsonia juglandis.—It is important to refer to this trouble in some detail for it has been confused with our walnut bacteriosis and bears a close resemblance to it in very many respects. This disease is caused by a fungus that is not uncommon in the Eastern States on the leaves of the butternut, *Juglans cinerea,* and on the leaves of the black walnut, *Juglans nigra.* So far as our observations have gone the trouble does not affect the nuts or branches of these trees. In France the fungus occurs on the nuts of the English walnut as well as on the branches, causing them to have a black appearance, like our Bacteriosis. This disease is described* by Prillieux and Delacroix of the Institute National Agronomique and Laboratoires de Pathologie Vegetale. No mention in this article or any other scientific literature is made of our Bacteriosis occurring in France.

In California no species of *Marsonia* is known to occur on English walnuts. There is a species of *Marsonia* recorded by A. D. McClatchie† as occurring on the leaves of *Juglans californica,* but this trouble is not at all common. In the spring of 1910 a species of *Gloeosporium* was found attacking the leaves of *Juglans californica.* This occurred only on the leaves and could not be confused with the *Marsonia* referred to in the following paragraph:

The following is an abstract from the article by Prillieux and Delacroix: *Marsonia juglandis* (anthracnose) is parasitic on leaves, young shoots and fruits of the *Juglans regia.* The disease forms round spots

*Maladies des Plantes. Les Maladies des Noyers en France.

†Seedless Plants of Southern California, p. 378.

on leaves, yellowish brown in color on the upper surface, and grayish brown on the under side. Hemispherical masses appear, the acervuli, as little pulverulent brownish bodies.

On the young shoots the color of the diseased portions is far different. Spots are irregular, shrunken, with edges more highly colored and

FIG. 78.—Bacteriosis on green shoots of English walnut.

thicker, bearing the pulverulent cushions of the fungus. The appearance of the disease on the shoots is a canker, reminding me of the true anthracnose of the grapevine.

Upon the fruits the parenchyma of the epicarp is invaded in its entire thickness by the parasite. The cankers on the fruit are browner than on

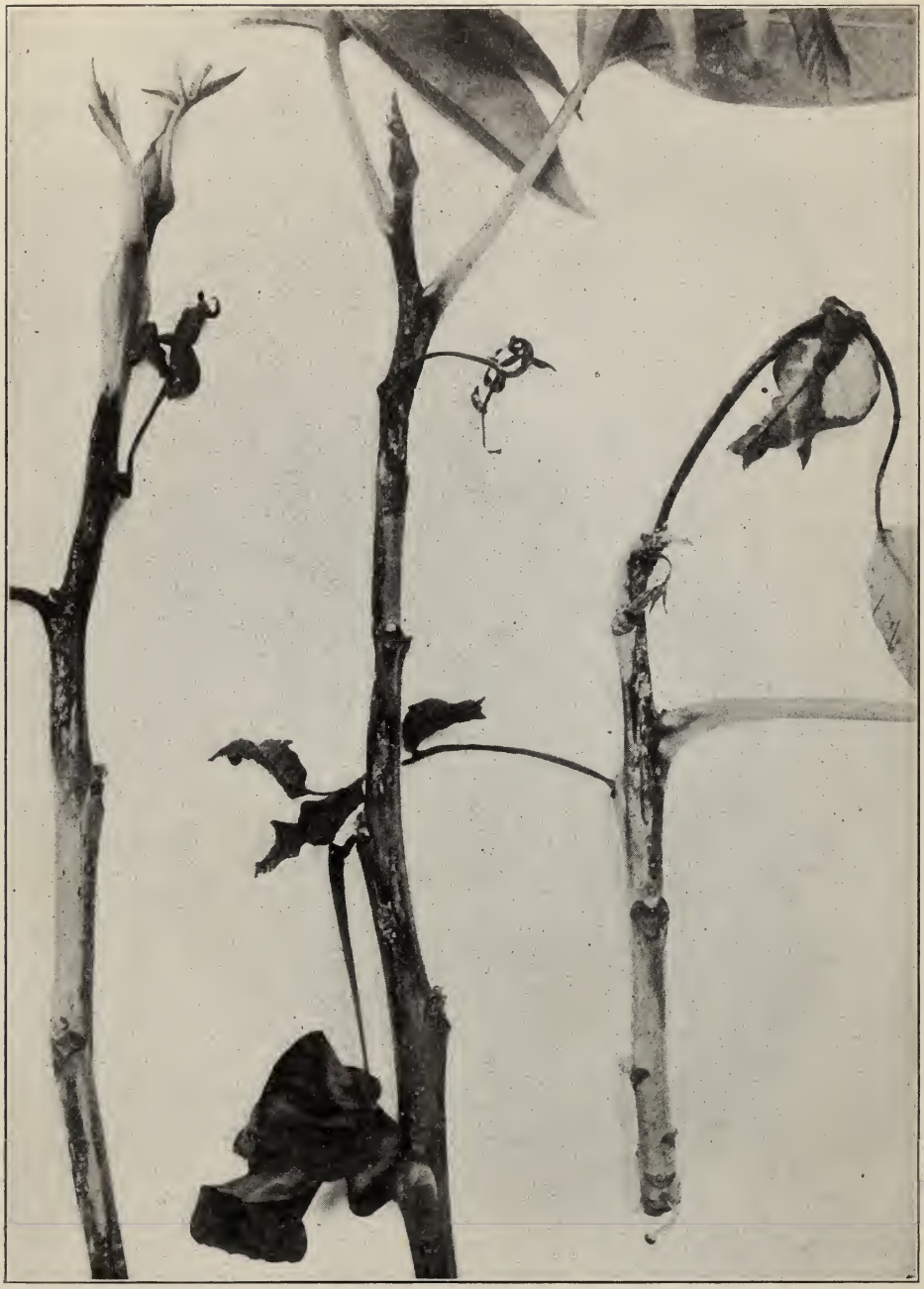

Fig. 79.—Bacteriosis on green shoots.

the shoots and are more spread out over the surface. The disease does most serious damage on the fruit and is worse in wet seasons and in certain valleys. If the disease starts early the nuts remain small and undeveloped and the amount of fruit is greatly reduced. The disease is frequent in walnut-growing sections of France. Bordeaux mixture has been tried for this disease and while it proved somewhat successful, yet it was too costly and difficult to apply.

Characteristics of Bacteriosis.—Walnut bacteriosis may occur on all the tender, new, growing parts of the tree, such as young nuts and branches, the petioles of leaves, as well as midveins, the fine lateral veins and adjoining parenchyma. On the affected parts characteristic blackish colored areas or quite pronounced lesions are produced. The blackening is, as Pierce suggests, brought about by oxidation of the tannic acid in the tissue. At any point of injury in the tender growth of the walnut a very similar black coloration will occur.

On Branches.—Bacteriosis is at first confined to small areas, but under favorable conditions these increase in size to a lesion or diseased area extending two or three inches in length on the green shoot. The disease always has its beginning on the young succulent growth which may be near the growing end or at any other point. When the disease infects a branch near its end, that part may be killed back, but this seldom occurs except when the diseased lesion is very near the end. In the worst diseased lesions the tissue is killed inwardly to the pith, while in less severe cases only the bark and wood are diseased. As the shoot becomes more woody it is more and more difficult to infect and no tissue ever becomes affected after the first few months of its growth. The disease after the first year, even in well defined lesions, gradually dies out and the tissue heals over the old lesion, although in some cases short lengths of the worst diseased shoots may die back for a few inches. The diseased portion on the twig at first forms a small, discolored or water-soaked area which gradually increases in size, and at length the central portion is black and is surrounded by a water-soaked margin or fermentation zone. As the shoot becomes more and more woody the active development of the disease is checked and no further tissue is involved. Then the whole diseased area becomes blackened in color. The diseased portion in many cases comes to have a somewhat shrunken, dried-out, deformed, cracked condition because of the killing and drying-out of the tissue.

During the spring when the flow of sap is active there is often quite an accumulation of liquid in the pith cavity beneath very badly diseased lesions. This liquid has been tested at different times to see if this was

*"Diseases of Walnuts," Bailey's Encyclopedia of Horticulture.

a source of infection. The test did not seem to show that the blight organism was present in any great abundance in this liquid. Pierce states* that the blight organism winters in the pith cavity, but we have not found the organism any more abundant in this place than in the partly live wood and bark of the diseased lesion. The diseased twigs of the previous year are without doubt the chief source of the initial infection each spring. From our study we believe the old lesions to be the only place where the organism can live over the dormant period of winter and start the first infection the following spring, although Pierce states that the old nuts and soil are a source of infection.

Bacteriosis is not Die-Back.—Walnut blight causes very characteristic, comparatively small, sunken, black areas on the small shoots of the tree. It does not attack branches of any size and does not injure them to such an extent that they die back for several feet, as in the case of die-back. See Die-Back, page 372.

On Nursery Trees.—Bacteriosis is especially severe in rapid-growing trees in the nursery. Walnuts are grown for two years in the nursery, being grafted the second season. The scions, after they start, usually grow rapidly and are in a very favorable condition for this disease to attack them. This infection in many cases comes from using diseased scions. Rapid sucker growth in the orchard is very apt to become infected and show the disease in a manner similar to that which occurs in nursery trees.

Leaves.—The leaves are sometimes diseased, especially the petioles and veins, which become a blackish or brownish color. The disease also attacks the parenchyma or soft tissue of the leaf, causing spots of a brownish color and of various shapes. These spots are rather common on rapidly-growing leaves, and especially on the very large leaflets of young nursery trees. The spots are circular or angular in outline and by confluence often cause quite large diseased areas. Here the small lateral veins in the diseased areas are a browner color than healthy ones. Fig. 80. The disease does not cause serious defoliation of the tree and should not be confused with the falling of the leaves that sometimes takes place after a period of hot weather during the summer months.

Catkins.—The catkins are probably not diseased by walnut bacteriosis. They often turn black, but this is probably only due to the natural process of dying and drying up after their work is done. Various attempts have been made to obtain the blight organism from these darkened catkins, but without success.

Nuts.—Bacteriosis on the young nuts is especially virulent and destructive under favorable conditions. The disease on the twigs and

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leaves ordinarily does very little injury and the disease would be of little economic importance did it not attack the nuts. Many of these may become diseased and fall when they are one eighth to one half an

Fig. 80.—Bacteriosis on leaves.

inch in diameter, and continue to drop more or less all through the summer. Pierce estimated a loss of from 50 to 80 per cent in badly diseased groves. We have never made a careful estimate of the loss

in actual per cents, but know that it is very heavy in some groves whenever the disease is severe. The loss may, however, be more apparent than real, especially when there is a heavy crop, as the relieving of the

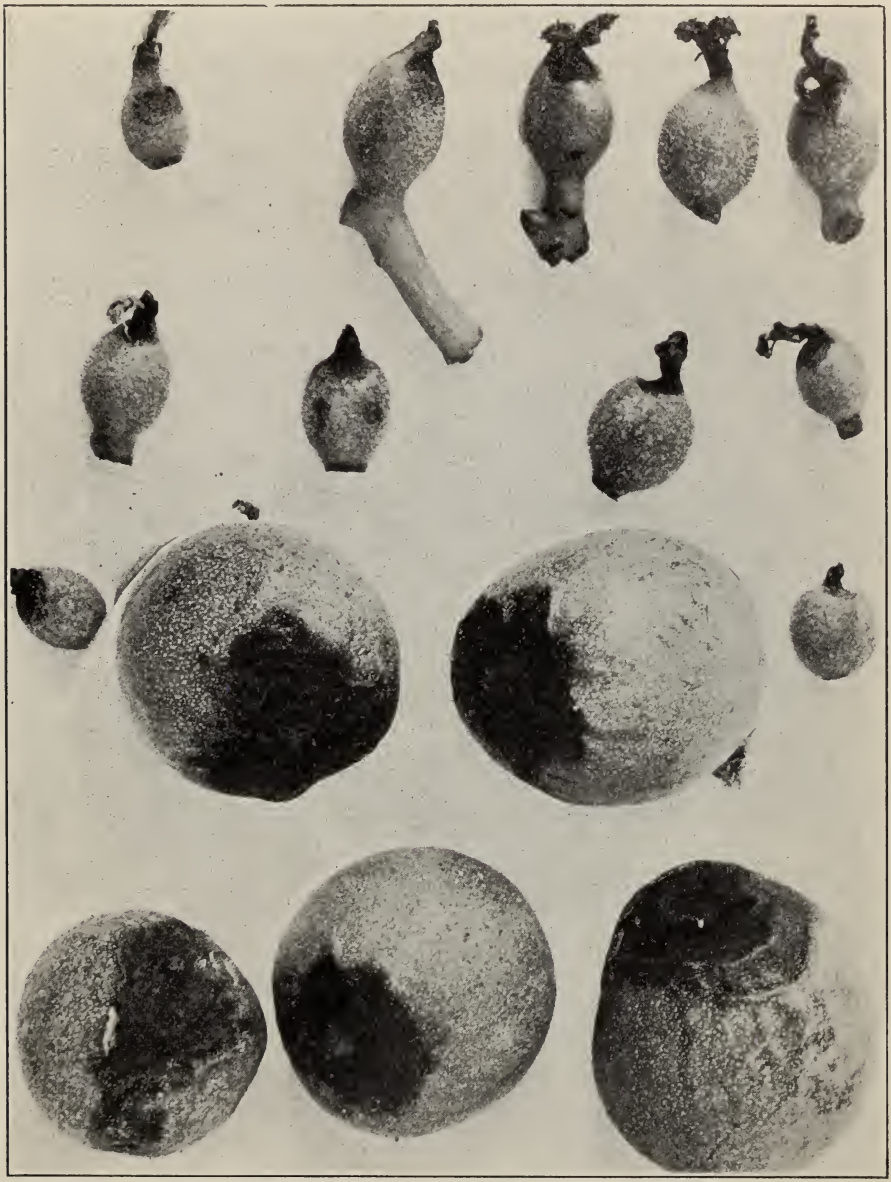

Fig. 81.—Walnuts affected by Bacteriosis, mostly stigma or blossom-end infection.

tree of a part of its load will better fit it to bear a good crop the following year, instead of periodic heavy and light crops. For the past few years, in spite of this disease, there have been good crops of nuts.

Young trees are much more free from bacteriosis than are those that have been in bearing for a longer time.

It should be remembered that other causes than bacteriosis may make the small nuts fall, as for instance poor pollination, which may result from a lack of pollen or unfavorable climatic conditions, the small nuts being very susceptible to cold at this time. In the English walnut the catkins and nuts are produced in the spring in separate clusters on the same tree. (See Fig. 1.) The catkins are the male flowers and bear the pollen. They are always found on the old wood, and these may be seen as rather long buds in the late autumn. The small nuts are found on the new growth. These two kinds of flowers should appear at about

Fig. 82.—Half-grown walnuts affected with Bacteriosis.

the same time, but on the seedling trees there is the greatest variation. A tree may have a very limited number of catkins or may be abundantly provided. These may appear at the same time as the nuts, or too early or late to be of much service in fertilizing them.

Blossom End Infection.—While the nuts may be infected at any point in the surface, by far the most common as well as most virulent form of infection is at the blossom end near what is technically called the stigma. This is the weakest part of the nut and is especially sensitive to the blight. The bacteriosis is very bad on the small nuts, and when once it has started at this point it rapidly continues its growth within the tissue, until the small nut is sufficiently weakened to fall. Not all

the infected nuts fall when they are small, but some remain on even until harvest time. In the nuts the disease gradually grows within the tissue until the kernel is reached which at length becomes blackened and then destroyed. The disease may start at any place on the nut and gradually extend through other tissues into the kernel, but by far the most of the infections that injure the kernel are from the blossom end.

Lateral Nut Infection.—The disease on the nuts starts at one or more points on the surface as a small, circular, raised, discolored area that at first has a water-soaked appearance and may not be larger than the point or head of a pin when first visible. The diseased area in its earliest stages is slightly raised above the surrounding healthy tissue, but as the disease progresses, the spot becomes more or less sunken below the normal tissue. The spot gradually enlarges in size and becomes black in appearance. Surrounding the blackened area is a paler zone, having the same water-soaked appearance already referred to. This band of tissue lies between the healthy tissue and the blackened area and represents the cells of the tissue that are being acted upon by the ferments secreted by the organism, which break down the tissue and prepare the way for the further advance of the bacteria. In the early infection, if climatic conditions are favorable, lesions or dark spots are formed which often extend through the hull and shell-forming tissues into the kernel. The nut in such cases is deformed in shape as the diseased part ceases to grow. Such nuts do not bark clean, as the outer covering clings very tightly to the shell, and the kernel at best is only poorly developed. Such nuts are usually never picked up from the ground, and in any case are only fit for culls.

Late Infections.—It often happens that during the summer months weather conditions are favorable for natural infection of nuts. At this time the outer tissue is beginning to harden and is not in condition for the deep growth of the disease that occurs earlier in the season when the tissue is more tender. Then, too, the disease may start in the surface rather late in the season and suddenly conditions become unfavorable for its further development, thus giving a very shallow, superficial development of the disease. These points of infection appear as small, dark-colored areas scattered over the surface of the nut. Each little infection can be distinctly seen, or its confluence with others may make a large spot. In these late infections the development is shallow and does not penetrate much through the epidermis, and the disease seems to dry out and die. Occasionally a more severe case of late infection occurs where the blackening and lesion extend to the hard shell, causing the hull to cling to the shell of the nut.

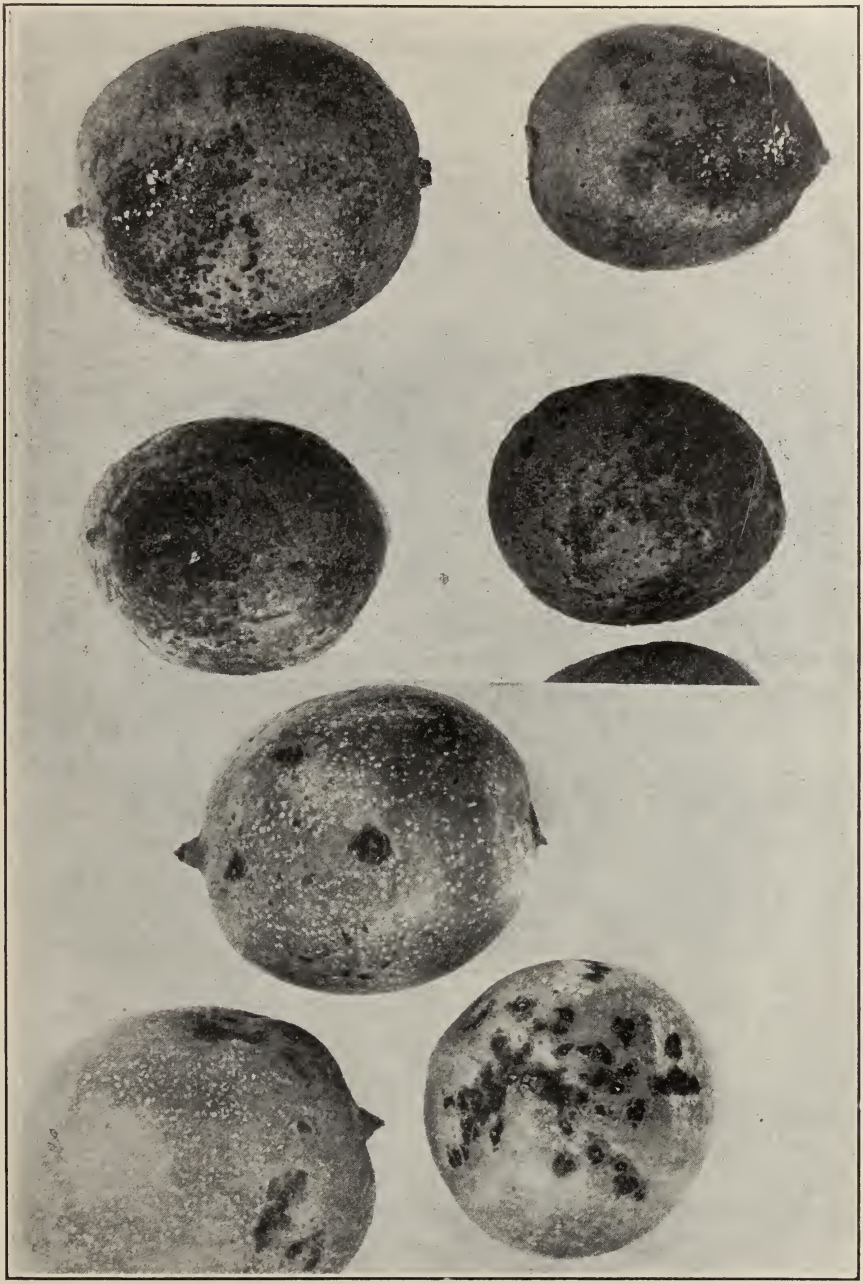

FIG. 83.—Walnuts with late infection by Bacteriosis.

White Deposit on Diseased Tissue.—On the surface of the diseased tissue of both the branches and the nuts can often be observed a whitish substance that accumulates during the summer but at length disappears. When this is properly stained and examined with a compound microscope, it is found to be composed of countless numbers of bacteria and broken-down plant tissue. Cultures made from this substance gave a large number of typical walnut disease colonies. A somewhat careful study was made of this white deposit in small nuts. Small diseased nuts having this white substance were put in 10 per cent chromic acid and the deposit swelled up and became soft and gum-like. It is thought that this white substance containing so many organisms is an important source of natural infection. Larger nuts, diseased at the blossom end, sometimes show gum-like streaks running down over the nut from the diseased portions. This substance also was found to contain bacterial organisms. From laboratory experiments it is known that the organism is quite resistant to desiccation and probably the condition described is an important factor in bringing this about.

Winter Habitat of Germ.—The germ of the organism without question winters in the old lesions of the branches. Much work has been done in making cultures at short intervals of time throughout the year from the different diseased tissues in order to see if the disease organism was alive and where it best could pass through the winter or dormant period. This work of making artificial cultures is given more in detail on page 343. The work began in October, 1907, and continued until the following spring, at which time the disease again appeared on the new growth. In every series of cultures the disease organism was found, showing conclusively that the disease was still alive in the old lesions of the wood and bark. The cultures made from the old nuts, both those on the ground and some still on the tree, gave some walnut blight cultures early in the autumn, but as the season advanced the organism seemed to die out and toward spring it was almost impossible to secure blight cultures from the old nuts found about the orchard. Pierce* states that the organism "winters in fallen nuts beneath the trees and probably upon fallen leaves and upon the soil." We believe that the old nuts are not an important source of infection, since in all well-cared-for groves these are plowed under before the tree starts out in leaf. This is especially true of those groves where a cover crop is sown. We have never tested soil and leaves to see if the germ could be found wintering in them.

The most prolific source of new infection is the lesions on diseased twigs. Here the germs remain in almost a dormant condition until the warm weather of spring, which arouses them to a renewed activity, when they exude on the surface and are carried to the new growth, leaves,

**Pacific Rural Press,* Vol. 57, No. 25, p. 387.

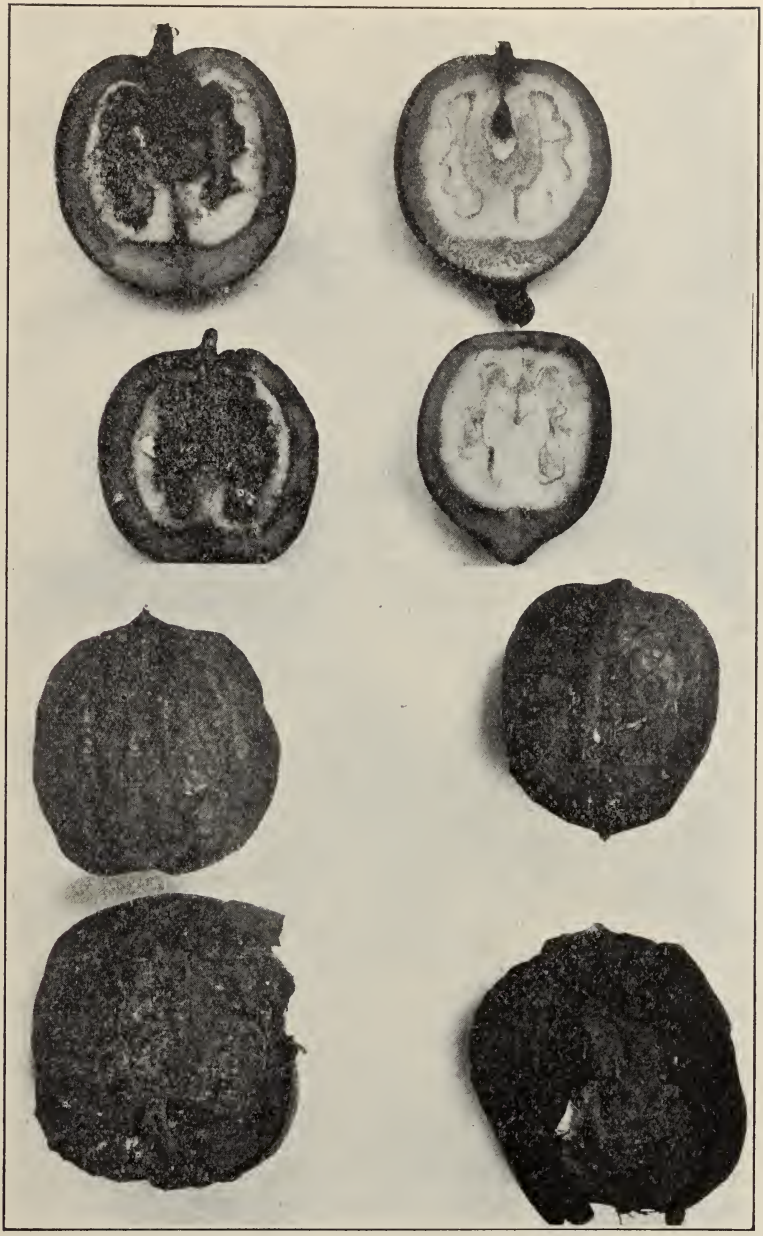

FIG. 84.—Above—Sections of two walnuts with Bacteriosis at the left, two normal nuts at the right. Below—Old, blighted nuts.

branches and nuts. From our observation, the young leaves seem to be infected very early and probably are one of the chief sources of the secondary infection.

Secondary Infection.—The first or initial infection may occur on only a few nuts and new growth, then quite suddenly the disease seems to spread and infect many small nuts. This sudden increase of the disease is due to an infection from the earlier diseased nuts and new growth, and can thus be termed the secondary infection.

Effect of Climate.—Walnut bacteriosis is a disease that is quite susceptible to variations in climatic conditions. It is a matter of com-

Fig. 85.—Bacteriosis lesions on older wood. Healing over.

mon observation among growers that the amount of blight varies from year to year in a given locality, also that some sections are freer from the disease than are others, even during the same periods of time. A given grove may be very bad one year and nearly free from the disease the following year. This is well illustrated by a comparison of the years

1907 and 1908. In 1907 there was an abundant amount of bacterial infection and quite a severe loss of nuts. There was at the same time a large crop of nuts. In 1908 there was almost an absence of blight and a very much lighter crop of nuts. It is rather difficult to always fully account for these variations because of the great number of conditions that must be considered.

Fogs and Moisture.—The amount of moisture present in the air has without question considerable influence on the quantity of disease that may develop, as humid conditions are especially favorable for its spread. It has been proven again and again by our experiments that infection is produced when water containing the disease germs is sprayed on the surface of the young nuts, while the untreated ones are free from the disease. Then, for infection to take place under natural conditions, it only becomes necessary for virulent germs to come in contact with immature nuts, and water is apparently the principal agent in conveying the germs from the diseased lesions to the young growth or small nuts below. Rains very rarely occur in the spring after the nuts appear, but foggy weather is often more or less frequent. What are called high fogs, a cloudy condition of the sky, but with little moisture, which in some sections occur during the spring months, do not cause infection, although such cloudy conditions are favorable for bacteriosis to develop where infection has already taken place. Low fogs and especially foggy nights are very favorable for the dissemination and new infection of the small nuts. During one of these fogs the trees become saturated, water dripping from one portion of the tree to another which could easily carry the disease organisms to healthy tissue. Observations go to show that the secondary infection, in which large numbers of the small nuts become diseased, is very likely to follow one of these foggy periods.

Insects.—It is more difficult to say just what part insects play in the spread of this disease, as it is not necessary for the nuts to be bitten in order to cause infection. Insects are present in quite large numbers about the tree. Several species of flies and beetles are most numerous. Flies have been observed on diseased nuts, probably attracted by the exuding of organic matter mixed with walnut blight germs that is sometimes present, and these flies have been collected and culture media inoculated by placing them in it, with the result that the characteristic organism has developed in the cultures. This shows that the living germs of walnut blight were on their bodies and only needed to be placed in contact with the nut to cause infection. A species of aphid is often abundant on the leaves, rarely on the nuts and branches. This insect, however, appears some time after the nuts, and probably does not cause much infection of any part of the tree except possibly the leaves. The honeydew is secreted and deposited on leaves and nuts, and in this a sooty mold grows.

How the Germ Enters the Tissue.—Nuts, as well as the leaves and young shoots, are provided with stomata or breathing pores through the epidermis into the interior of the tissue. These stomata on the nuts are arranged in groups of from five to a dozen or more, and are to be found on the paler green specks that spot the surface of the husk of the green nuts. It is through these openings that the bacterial organism can gain entrance to the interior of the tissue of the young nuts.

The blight organism is motile and when carried to the surface of the nut by moisture, such as fogs and heavy dews, can use this moist surface to swim directly into the stomata or breathing pores just described. When once in the interior of the nut the conditions are favorable for further development. While these stomata have the power to open and close, they are probably never so closely shut that the small germs could not enter. The moist conditions favorable for the entry of the germ or bacterium through the stoma are also just the conditions necessary for keeping this entrance open.

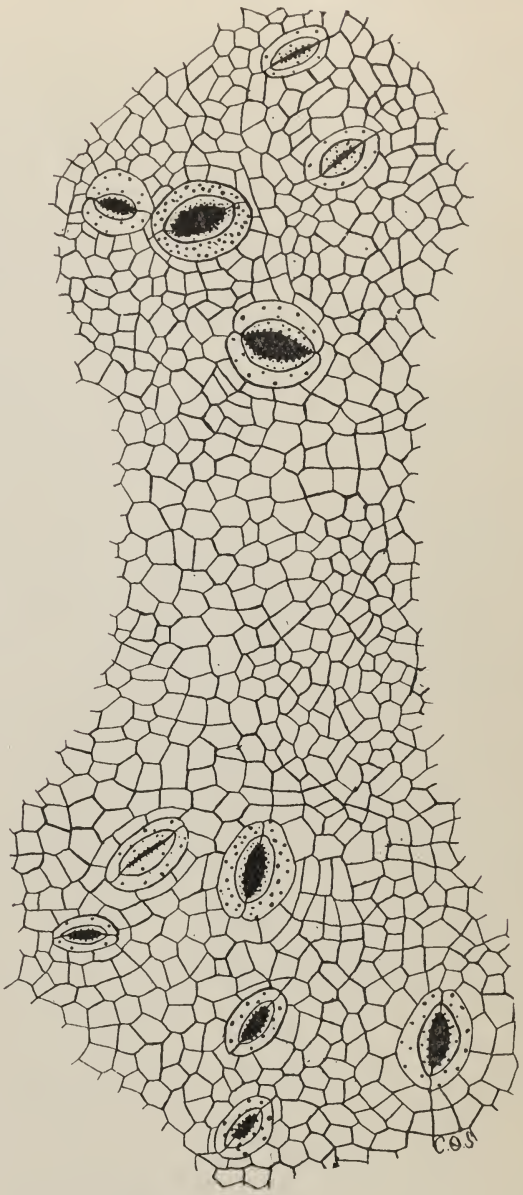

FIG. 86.—Surface of green walnut, showing two groups of stomata through which the blight germ enters. Much enlarged. Each group represents one of the light-colored spots on the surface of the green hull.

Two Seasons Compared.—The two years of 1907 and 1908 well illustrated the two extremes of much and practically no bacteriosis of the walnut. The year 1907 was very favorable for the development of this trouble, while

the following one showed comparatively little of the disease. It will be instructive to observe a few of the reasons for this difference.

The winter of 1906 and 1907 was a rather wet season, there being about 20 inches of rainfall in the vicinity of Los Angeles. The spring opened very early, some walnut trees beginning to show leaves during the last week in February. Some of our preliminary inoculation work was done at this time, February 22d. Small nuts appeared early in March, and on March 7th we inoculated our first small walnuts for bacteriosis. It is safe to say that the season was at least three weeks in advance of the average time of blossoming, which gave a longer period favorable for infection to take place. This is an unusual situation, and has not been repeated.

The winter of 1907 and 1908 was a dry winter, there being about twelve inches of rainfall in the regions around Los Angeles. The earlier trees began putting out leaves about April 1st. Too much importance should not be given to the difference in the amount of rainfall of the two years, as its relation to the amount of bacteriosis is exceedingly doubtful.

Another favorable condition of 1907 was the cloudy weather during March, April and May, the time of year when the bacteriosis is most active, as compared with the conditions of the same period during the following year. This is well shown in the following table compiled from data very kindly furnished by Mr. A. B. Wollaber, the local forecaster of the United States Government Weather Bureau at Los Angeles. It is well known that sunlight is fatal to most kinds of bacterial germs and the walnut bacteriosis is no exception to this rule. The table shows that the nuts during the spring of 1908 had a much greater amount of sunshine during their first three months of growth than did those of 1907 during the corresponding three months. May not this in some measure be the reason for the difference in the amount of this disease during these two years?

TABLE I.

Showing average daily hours of sunlight for periods of five days.

Date.	1907.			1908.		
	March.	April.	May.	March.	April.	May.
1–5	5.4	7.8	6.1	7.1	10.5	9.8
6–10	6.8	10.7	9.7	10.9	8.5	12.9
11–15	10.0	3.3	11.5	11.8	11.3	9.6
16–20	5.6	8.3	11.9	5.2	11.0	12.7
21–25	4.9	7.4	10.8	9.3	8.1	9.3
26–end	9.8	2.9	4.8	10.6	11.6	11.6

1907—March had 3 days with 1 hour or less of daily sunshine.
March had 7 days with 2 hours or less of daily sunshine.
April had 6 days with 1 hour or less of daily sunshine.
April had 15 days with 6 hours or less of daily sunshine.
May had 2 days with 1 hour or less of daily sunshine.
May had 9 days with 6 hours or less of daily sunshine.

1908—March had 1 day with 1 hour or less of daily sunshine.
March had 3 days with 2 hours or less of daily sunshine.
April had 0 day with 1 hour or less of daily sunshine.
April had 2 days with 2 hours or less of daily sunshine.
April had 2 days with 6 hours or less of daily sunshine.
May had 0 day with 1 hour or less of daily sunshine.
May had 2 days with 6 hours or less of daily sunshine.

Average amount of possible daily hours of sunshine in California for March is about 12 hours; for April, 13.5 hours; for May, 14 hours. For April, 1907, there was 52 per cent of the possible amount of sunshine; for April, 1908, there was 78 per cent; for May, 1907, there was 65 per cent of the possible amount of sunshine; for May, 1908, there was 74 per cent of the total number of hours.

Non-blighting of Late Blooming Trees.—As previously stated in the comparison of the two seasons, the season that opened late, that is 1908, had almost no walnut blight. What was true of the majority of bearing trees during that season is always true of trees that bloom late. The majority of the bearing orchards of California are at this time seedling trees, differing greatly in their blooming periods. The difference in time is frequently from one to two months and may be as much as three months between the earliest and the latest French varieties. Such a wide range in time of blooming gives considerable chance for difference in climatic conditions. We find that the early or medium blooming trees are in blossom at a favorable period for the blight to develop while the late bloomers come into flower at a time when bacteriosis can make little headway. Particular attention has been given to this phase of our investigation in the hope of finding a commercially profitable tree that blooms at a season when conditions for the infection of the small nuts is at a minimum. While this work is not yet completed

enough has been done to show that nuts in such late trees are comparatively free from the disease. Some of these late varieties are described in another part of this bulletin.

Immunity.—Certain trees are some times spoken of as being immune to the blight, but while there is probably no such thing among walnuts as absolute freedom from this disease, where conditions are favorable for blight infection, yet some trees do show quite a marked resistance, and, if otherwise desirable, are given precedence in new plantings on this account. (See Eureka, etc.) It may be that in certain localities there is no blight, but this probably is not due to any immunity that the trees possess but is rather the effect of climatic conditions or due to the fact that the specific organism has not yet reached this particular locality.

Isolation.—Pure cultures of the walnut bacteriosis are most easily obtained from recently diseased nuts, although they have also been secured from diseased leaves, old lesions and young blighted shoots, as well as from certain flies that are quite abundant about walnut trees during the period of infection.

Table showing dates and results from various attempts to isolate the walnut blight organisms from diseased tissue.

1907.	Diseased tissue.	Number of isolations.		1908.	Diseased tissue.	Number of isolations.	
		+	—			+	—
Oct. 25	Pith	0	1	Feb. 4	Wood and bark	1	2
	Wood and bark	1	0		Wood	1	0
	Wood and pith	0	1		Nut from tree	1	0
	Bark	1	0	13	Five nuts	0	5
	Inside hull	0	2		Wood and bark	0	1
Nov. 5	Pith	4	0	19	Wood and bark	3	1
	Wood and bark	3	0		Wood	1	0
6	Green hull	0	1	Mar. 2	Wood and bark	1	2
	Dry meat	0	2	12	Wood and bark	2	3
16	Bark	1	0	16	Wood and bark	0	3
	Wood and bark	3	0	24	New growth	0	1
	Pith	1	0	30	Pith	0	1
26	Wood	1	0		Nut	0	1
	Bark	2	0		Wood	0	1
	Leaf petiole	0	1		Wood and bark	1	0
	Portion hull	0	1	Apr. 3	Wood	0	1
	Healthy bark	0	1		Wood and bark	2	0
Dec. 3	Bark and wood	1	2	8	Young nuts	2	0
	Healthy bark	0	1		Young shoots	0	1
	Blackened shell	0	1		Petiole	0	1
12	Wood and bark	4	3	14	Small nuts	2	0
19	Wood and bark	2	2	17	Blackened leaves	3	0
26	Wood and bark	0	8	21	White substances on surface of lesion	3	0
1908.						—	—
Jan. 7	Wood and bark	2	8		Totals	23	24
	Wood	0	2				
	Nut on tree	1	0				
16	Wood and bark	4	0				
	Wood and pith	0	2				
30	Wood and bark	2	2				
	Nut from tree	0	1				
		—	—				
	Totals	33	42				

The usual method of securing pure cultures was as follows: A scalpel sterilized by flaming was used to remove the outer blight portion of the young nut. Then some of the diseased interior of the nut was transferred to liquid media, such as acid Dunham solution or acid peptone meat bouillon. About twenty-four hours after inoculation there is usually some evidence of growth and dilution cultures were then made in nutrient agar. In two to five days at a temperature of 20° C. the colonies will appear and can then be transferred to potato cylinders or other solid media. The organisms are usually abundant enough in the diseased nuts to plate out directly from the diseased tissue without incubation.

The preceding table shows that the organism was alive at all seasons of the year in the different diseased tissues. The number of isolations was not at any time very great, but sufficient to show a large number of positive results. The negative results obtained do not mean there was lack of growth in the tubes inoculated with the diseased tissue, but that there was usually some other sort of bacterial growth. There are several kinds of saprophytic organisms that can be found in these old lesions. In the dilution cultures a saprophytic yellow organism was very often present and could not always be distinguished in color or manner of growth from that of the walnut bacteriosis. The difference in growth on potato cylinders, however, readily distinguish the two. Even when lack of growth did occur, too much importance should not be placed upon it, for the walnut blight organism grows more slowly than do the saprophytic organisms and could readily be crowded out by them in artificial cultures.

A MORE TECHNICAL STUDY OF THE WALNUT ORGANISM.

Pseudomonas juglandis Pierce.

MORPHOLOGY.

These characteristics were studied in bouillon, agar and potato cultures from twenty-four to forty-eight hours' growth, except in old cultures that have been examined for spores.

Form.—The organism has rounded ends and occurs as single rods or often in pairs, and more rarely in chains of several individuals, commonly four to eight.

Size.—The rods as found in diseased tissue and stained with carbol-fuchsin measure 1.5 to 3.01 microns in length by 0.3 to 0.51 microns in width.

Staining Reactions.—The organism stains readily with the usual bacteriological stains, carbol-fuchsin, aniline gentian violet, aqueous solution of methylene blue, gentian violet, and by Gram's method. Nothing especially characteristic was observed from the use of the various stains.

Spores.—No spores from this organism have thus far been demonstrated. Old cultures have many times been studied and special stains used. Hauser's method was used, but did not show anything suggestive of spores.

Capsule.—The organism has never showed a true capsule, although its viscid growth might suggest one, and a microscopic examination of this viscid growth from potato cylinders and other culture media often shows a very distinct and rather thick wall, that can easily be seen by using some of the special stains recommended for capsules. This may appear as a hyaline membrane from one fourth to one half as thick as the remaining width of the organism. The following capsule stains were used: Robberts' dahlia, Welch's and Bonis'.

FIG. 87.—1, the walnut blight organism, *Pseudomonas juglandis,* greatly enlarged; 2, a mass of the bacteria in diseased walnut tissue.

Flagella.—The organism is motile by means of a long, single polar flagellum, as may be demonstrated by using Bowhill's method. The movement of the organism is a slow, sinuous one in the direction of the longer axis.

CULTURAL CHARACTERISTICS.

The culture media were carefully prepared, following directions as given by Smith[1] and Moore.[2] The formula for preparing nutrient bouillon was Witte's peptone 10 grams; (c.p.) sodium chloride 5 grams; 500 grams of finely minced beef to 1,000 c.c. of once-distilled water. In making this the directions given by Moore were followed.

[1]Bacteria in Relation to Plant Diseases.
[2]Laboratory Directions for Beginners in Bacteriology.

Agar Plates (Surface Colonies).—In beef peptone acid agar, plus 15 Fuller's scale, temperature 17° to 18° C., the colonies became visible after forty-eight hours as minute whitish specks that changed with growth to straw color (stramineus),* and at length to a lemon yellow. After five days' growth at 18° C., the surface colonies measured 1.5 to 2.5 mm. in diameter. At this time they are straw color (stramineus),* and appear raised to the eye, especially at the center, where they are a deeper yellow color, or nucleated. This nucleated character of the colony is quite constant, being observed even in quite small colonies. The colonies are nucleated, circular, moist, shining, pale yellow with regular margins. When examined with the low magnifying power of the compound microscope the margins are coarsely granular, while the center has a finer and denser granular structure. Under the low power magnification the colony is seen to have several concentric zones which probably represent different regions of growth. The margins are entire or slightly undulatory. After twelve days' growth the colonies have become 5 to 10 mm. in diameter and are still zoned when examined microscopically. The center of the colony (nucleus) is a pale lemon color, while the margin is of a still paler yellow.

Deep Colonies.—These colonies are at first white, but later become lemon color. They vary somewhat in shape, being biconvex, angular, or oval to circular in outline.

Agar Slant.—On acid meat peptone agar after twenty-four hours incubation at 18° C. there appears a slight whitish growth along the streak and on the adjacent surface of medium. In five days there is a fairly abundant growth spreading on either side of the streak. Growth shining, pale lemon-yellow (W. and N.)† with wavy margins. In ten days growth covers entire surface of medium and often shows small colonies at side of main growth. In the older tubes there sometimes appears a whitening of the agar just beyond the line of growth. This same characteristic was also observed on litmus lactose agar, as well as on stab cultures of both of the agars. This characteristic, however, is not a constant one, and was only observed a very few times.

Agar Stab.—On acid meat peptone agar after twenty-four hours at 18° C. growth takes place along the line of puncture and on the surface of medium around the puncture. Growth on surface piled up, yellowish. The growth along puncture tuberculate-echinulate (Chester's terminology).

Carbohydrate Agars.—The organism was grown in 5 per cent dextrose, lactose and glycerine agar. Shake cultures were made in each

*Chromotaxia seu Nomenclator colorum—P. A. Saccardo.

†Winsor and Newton's specimen tints of oil and water colors. Plate 5.

of the above agars, as well as in plum agar. In three days at 24° C. there was fine growth at surface of medium in each case, but no growth deep in medium in tubes and no indication, at any time, of gas formation. The walnut organism seems to be a strict ærobe.

Litums Agars.—The walnut organism was also grown on litmus lactose, litmus galactose, litmus dextrose media and litmus saccharose. This was made up as follows: Distilled water, 2 per cent Witte's peptone, 0.5 per cent (c. p.) sodium chloride, 2½ per cent agar, and 2 per cent of the above-named sugars; titration was plus 12 Fuller's scale. In three days at 23° C. there was abundant growth along the line of puncture and over surface. The cultures in galactose after seventy days showed slight reddening of the agar near the bottom of the tube, but not nearly so decided a reaction as was secured with the olive organism, *Pseudomonas oleæ* (Arc.) Trev. In the litums dextrose and litmus lactose there was no visible change in color of medium, even after two months' growth.

Gelatin.—Ten per cent gelatin and beef peptone bouillon was used. After twenty-four hours at 20° C. there was a slight yellowish growth along the line of puncture. Liquefaction begins within a short time at the surface. The type of liquefaction is crateriform (Chester's terminology), the liquefaction being at first restricted to the mouth of the stab and forming a deep pit. As growth continues the liquefaction extends laterally, and in about five days the upper portion of the gelatin in the test has become liquefied and would be termed stratiform. However, after a layer of liquefied gelatin has formed, further liquefaction at 17° C. is very slow and does not take place at all along the line of puncture. It often requires a month for the 10 c.c. of gelatin in the test tube to be entirely liquefied.

Potato.—Growth abundant, moist, shining, slimy, raised and piled up, forming a thick coating that in about two months becomes viscid, finally filling up the fluid with a yellow, slimy growth. Color of the growth on potato cylinders was at first white, changing in a few days at 18° C. to sulphureous (Sacc. Chrom.), and in about six days to a pale lemon yellow (W. and N.). At the end of a month the color frequently became citron yellow (W. and N., plate No. 5). In cultures two months old the color changed to raw umber shade (W. and N.)

The growth on sterilized potato is very characteristic because of the white fermentation band that appears just beyond the margin of growth. This can be observed on potato cylinders, or better still on slices of potato sterilized in petri dishes. The white zone usually is visible within three days from inoculation when the organism is growing at a temperature of 20° C. to 26° C. In a few days the fermenta-

tion band spreads over the entire surface of the potato slices. The starch where growth has taken place fails to give normal starch reaction when treated with iodine, but gives a reaction for grape sugar. This fermentation band is quite a constant characteristic and usually appears. When the organism is growing slowly and at a rather low temperature, the fermentation band is more likely not to show.

The organism lives for several months on potato cylinders, having been found alive at the end of four months when growing at a temperature of 15° to 18° C. In some cases the cultures die after three months. In the old tubes the cultures are very viscid and much darker in color, raw umber. (W. and N.)

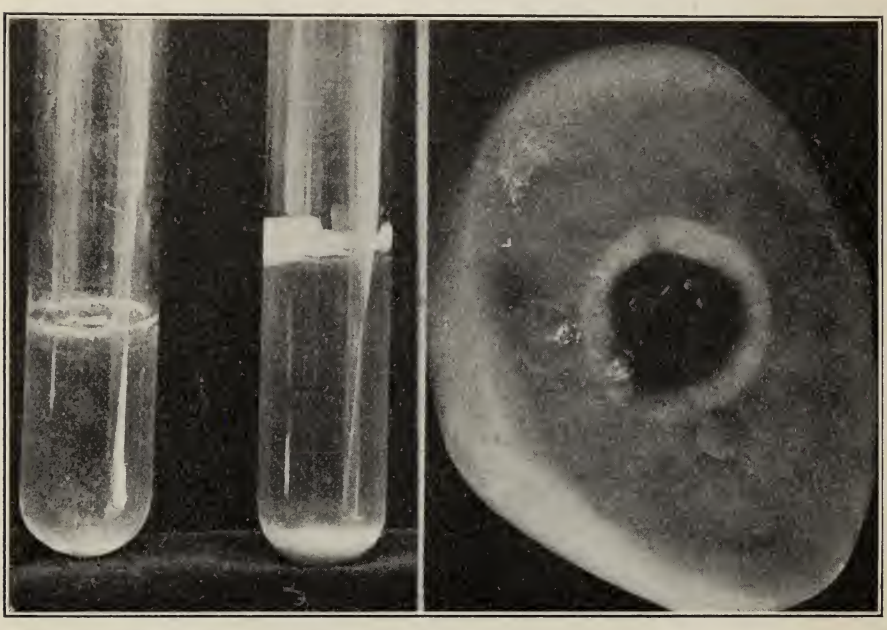

FIG. 88.—Typical growth of *Pseudomonas juglandis*: left in glucose bouillon, right on potato.

Fermentation Zone.—Special attention was given to the study of this fermentation zone. Early in the study it was found that this was a varying characteristic, one that appeared constantly during the warm weather of the spring and summer, but failed to appear during the cooler winter weather. This point was tested experimentally by sterilizing two series of five petri dishes, each containing slices of potato heated at 110° C. in autoclave for fifteen minutes. These two series of five plates each were inoculated at the same time and from the same culture. Both series of cultures grew well. Series I at a temperature of 12° to 15° C. This we did not vary for five days from 15° C. Growth was as vigorous as in those at the higher temperature. No

fermentation zone was observed during the fourteen days of the experiment.

In the incubator at 23° to 26° C. growth began to show after twenty-four hours. In forty-eight hours on December 16, 1908, the growth had increased and was very vigorous and the fermentation zone was just beginning to appear in all of the five cultures as a very faint. whitish line outside the margin of growth. This zone constantly became more evident, and on the fourth day from inoculation was at its best. Further growth was slower and no great change was to be observed during the two weeks of observation.

Professor Pierce in his study laid stress upon this characteristic to separate the walnut organism from the closely related species, *Pseudomonas campestris.* To test this, we secured a culture of the latter organism from Dr. H. A. Harding of the Geneva Experiment Station of New York State. On July 1, 1911, potato slices were inoculated in the same way as has already been described. Black rot of cabbage (*Pseudomonas campestris*) and walnut organisms were used. July 5th, the two series of cultures were examined. Both cultures from the incubator at 26° to 28° C. showed fine fermentation zone formation. In fact, it would be difficult to distinguish one from the other. The culture of the walnut organism grown in the culture room at a temperature of 20° C. showed very good fermentation zone formation, while that of *Pseudomonas campestris* was much less developed. Dr. H. A. Harding, in his study of this organism, speaks or a "white margin or halo just outside of the line of growth."*

Other Solid Media.—The organism was also grown on slices of sweet potato, turnip, garden beet and carrot, Irish potato being used as a check. Slices of these vegetables were sterilized for fifteen minutes in the autoclave at 110° C., then inoculated from the same source and grown in the incubator at 23° to 26° C. for several days. After six days there was abundant growth on each of the different vegetables, but nothing characteristic on any of these media except that of the Irish potato where the white fermentation zone appeared, as has been before described.

Bouillon.—On meat peptone bouillon, plus 15 Fuller's scale, the organism grows well, and in forty-eight hours at 18° C. the liquid is uniformly turbid. In seven days there is a slight flocculent precipitate at the bottom of tube. A true pellicle has never been observed to form over the surface of this medium, but a ring-like growth develops readily at margin of liquid on the surface of test tube.

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*New York Agricultural Experiment Station, *Geneva,* Technical Bulletin No. 13.

Dunham Solution.—The growth in this medium shows very much the same characteristics as in bouillon. In cultures over a week old the liquid is clouded.

Carbohydrates in Bouillon.—The walnut organism was grown in the following bouillons, containing, respectively, 2 per cent glucose, dextrose, lactose and glycerine saccharose. These solutions were made up by adding the carbohydrate to a solution of meat peptone, solution made after the formula: 1 per cent Witte's peptone, 0.5 per cent sodium chloride, 0.5 per cent Liebig's meat extract. These solutions titrated plus 12 Fuller's scale. Growth took place within forty-eight hours, and at the end of five days fine growth showed in all the tubes of this series. The glucose series of tubes showed a well developed ring formation, while in the other media there were traces of ring formation, but much less than in glucose. There was no complete pellicle observed in these tubes. They were titrated, but showed no increase of acid.

Cohn Solution.—Formula as given by E. F. Smith was used.* Five tubes were inoculated with forty-eight-hour culture of walnut organism, but after three months there was no growth in tubes.

Milk.—The cream was removed from milk that had set over night in an ice box. The same was filtered and sterilized in steam sterilizer. Reaction was plus 10 to 15 Fuller's scale. These tubes were inoculated and grown at temperatures 25° to 27° C. In three days the separation of the casein was first observed. The coagulum is formed rather slowly and even after five days there is little separation of the whey, and no pellicle to be seen at this time. The curd and whey gradually separate from each other, the former becoming solid. The casein is soon acted upon by another enzyme and is gradually redissolved, probably by a trypsin ferment. This process of digestion takes place usually rather slowly, several months often being required for completion. After a month the white curd may be observed at the bottom of the tube while the liquid above is of a yellowish color (yellowish straw color).† At first the whey is clear and nearly colorless, but changes to a yellowish color, as stated above, when reabsorption of the casein has taken place. Upon a microscopic examination of the liquid directly above the casein that is in process of reabsorption many crystals can be seen. The most conspicuous of these are long, needle-like crystals. A pellicle at length forms on the surface of the liquid in the milk tubes.

Litmus Milk.—The characteristics are very much like those just given for milk. Separation of casein takes place by a rennet ferment, or rarely digestion occurs without casein separation; the tubes under these

*Bacteria in Relation to Plant Diseases.

†Repertoire de Couleurs, Henri Dauthenay.

conditions have a wine-colored liquid. Litmus was slowly changed so as to give a pinkish or wine-colored appearance to liquid, sometimes after one to two months.

Methylene Blue Milk.—This medium was made by adding 2 per cent aqueous solution of methylene blue (Merck) to milk and sterilizing same. In one to two days at 19° to 20° C. the color completely disappeared and could be restored by boiling or shaking the liquid in the tube a few minutes. The disappearance of color seems to take place first at the lower part of tube. The color entirely disappears some time before separation of casein can be detected.

Plant Juices.—The walnut organism grows well in plant juices. While no great number has been tested, the following extracts gave abundant growth: Leaves of walnut (*Juglans regia*), loquat, castor bean and fig. A ring formation and pellicle as well as a flocculent precipitate are produced in these media.

Viability in Media.—In order to test the period of viability, transfers were made to potato cylinders from milk culture at the end of five, seven and eight months. Growth resulted in several cases. Old potato cylinders were also tested. All these cultures were growing in dark at a temperature from 15° to 20° C.

From potato cultures made December 10, 1910, transfers were made on September 28, 1911, a period of about nine and one half months. On October 4, 1911, there was growth in one of the two tubes tested, the other showing fungus growth. These old potato cultures just referred to seemed to be thoroughly dried out, hard, and for the most part brittle. When placed in the liquid of the potato cylinder tube the old, dried-out portion absorbed water, becoming swollen and more like its former viscid condition. Another potato culture six and one half months old also produced fine growth when transferred to sterile potato cylinders. In these cases of old potato cultures it is perhaps more an instance of resistance to desiccation, also possibly this resistance may be due to spore formation, although these have never thus far been demonstrated.

Indol.—This reaction was tested in Dunham solution made as follows: Witte's peptone 1 per cent, sodium chloride 0.5 per cent, and distilled water. After two weeks, the cultures were tested for indol with sodium nitrate 0.02 per cent and a few drops of concentrated sulphuric acid. The tubes after treatment did not at once show the characteristic pink reaction, but when warmed for five minutes at 75° to 80° C. in a hot water bath, a strong indol reaction resulted, the color being deep cherry red.

Nitrate Reduction.—A meat-peptone medium was used that titrated plus 12 Fuller's scale. It was made after this formula: 1 per cent

Witte's peptone, 0.5 per cent sodium chloride, 0.5 per cent Liebig's meat extract, 0.5 per cent potassium nitrate (Merck). Good growth took place in these tubes after five days at 25° to 27° C. They were tested by the KI H_2SO_4 starch method as recommended by E. F. Smith.* Not the slightest nitrate formation was shown in any of the tests.

Enzymes.—The walnut organism produces at least four enzymes, diastatic (starch-destroying), cytohydrolytic (cellulose-dissolving), rennet (casein-forming), proteolytic (peptonizing). Professor Pierce states† in his article on this disease that he found that these enzymes are especially active at a temperature between 65° to 75° F., and this agrees very well with our study of growth of the organism on potato slices and the accompanying fermentation zone.

Attention was called by Professor Pierce to the marked similarity between the organisms of walnut bacteriosis and the black rot of the cabbage. While few comparative studies have been made, yet the cultural characteristics of the two are very similar indeed. The few cross-inoculations made with *Pseudomonas campestris* on walnut and *Pseudomonas juglandis* on cabbage show that the pathogenic properties are distinct. The walnut organism also grows more readily on plant juices.

The group number of the organism, in accordance with the system prepared by the American Society of Bacteriologists, is 211.3332513. It will be observed that this is identical with that of *Pseudomonas campestris.*

ARTIFICIAL INOCULATIONS.

Methods.—Inoculations have been successfully made at various seasons of the year and in two different ways, by puncture and by atomizing. The puncture method is the most likely to give positive results. A sterilized needle is used to transfer some of the germs from a pure culture into a wound made by a slight pricking of the surface. The atomizing method was used also quite effectively on the young nuts, but gave no results on foliage or the young shoots. A young pure culture of the walnut blight organism grown on potato for about three days was mixed with distilled water and the mixture sprayed on the nuts or shoots with an ordinary medical atomizer, without injuring the tissue. This experimental work has extended over two seasons. The season of 1907 was one favorable for blight development from natural infections, while that of 1908 produced very little walnut blight. The time and results from atomizing during 1907 and 1908 are given in tables which follow.

Atomizing on Late Tree.—The results summarized in the following

*Bacteria in Relation to Plant Diseases.

†Bailey's Encyclopedia of American Horticulture, p. 1961.

table represent work done by spraying healthy nuts with a water solution of the organism on a rather late blooming tree, being in blossom from the middle to the last of April. The nuts were always very free

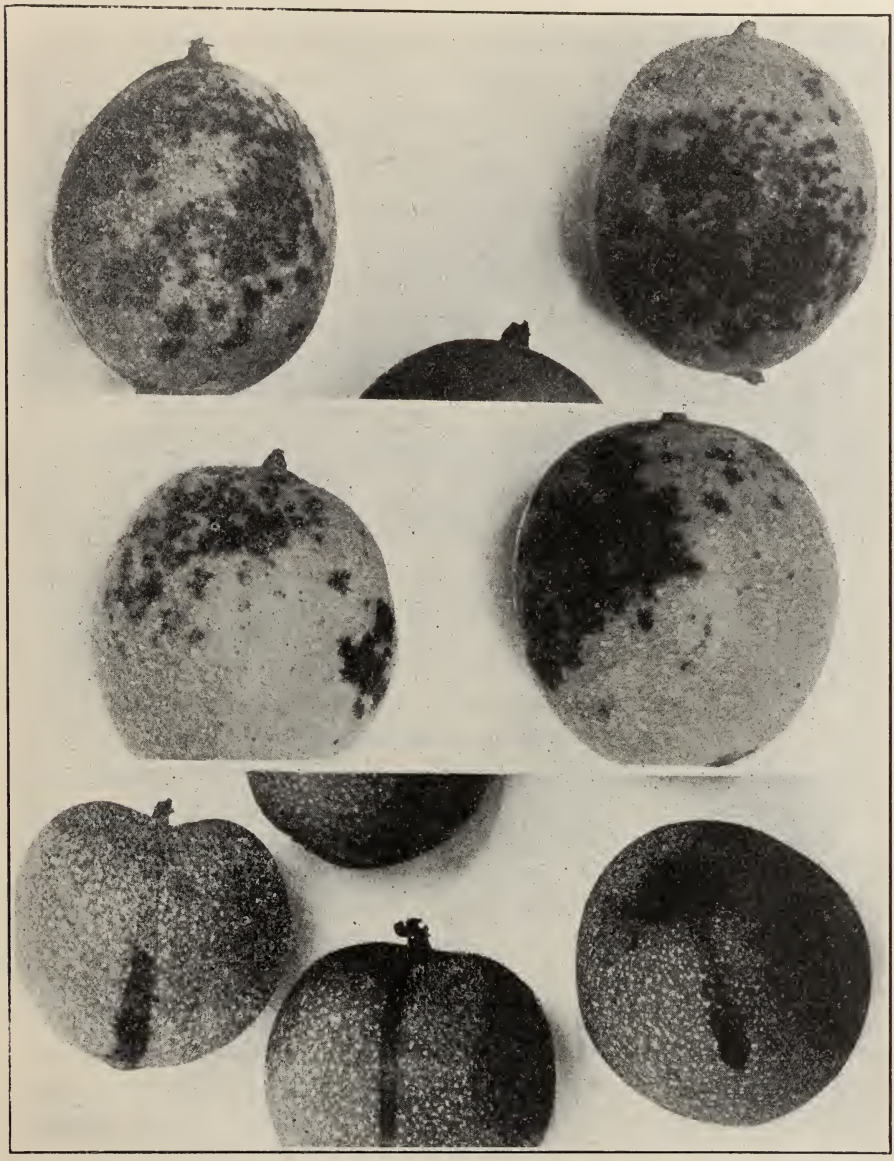

Fig. 89.—Below—Stigma exudation from blighted nuts. Above—Nuts artificially infected with Bacteriosis.

from blight, and when the atomizing work was begun no blight of any kind could be found on this tree nor did it ever develop to any extent at other points than those that were atomized.

Atomizing results on nuts of late blooming tree with water solution of the walnut blight organism from pure cultures, at different periods.

1907.	Nuts atomized.	Diseased nuts.	Healthy nuts.	Date of observation.
April 27	28	20	3	May 27
April 29	15	7	4	June 8
May 2	6	5	0	June 1
May 16	22	14	8	June 1
May 20	18	18	0	June 1
June 8	76	65	1	June 24
June 26	42	30	7	July 16
June 27	5	5	0	July 16
June 29	15	9	5	July 23
July 2	10	7	3	July 23
July 3	16	15	0	July 23
July 6	5	0	4	August 13
July 7	2	1	1	August 1
July 9	25	20	3	August 1
July 13	67	28	35	August 14
Totals	352	244	74	

The table shows that a total of 352 nuts were atomized at the different dates and that 244 or about 69 per cent of those treated contracted the disease. Thirty-five of the treated nuts dropped before final results were obtained and were not counted in the results, although the chances are that a large number of these were also diseased and would still farther have increased the percentage of diseased nuts.

Table showing results from atomizing nuts on an early-blooming tree.

Experiment.	April, 1908.	Number culture.	Nuts atomized.	Observation.										
				April 1908.	Diseased nuts.	Fallen nuts.	April 1908.	Diseased nuts.	Fallen nuts.	April 1908.	Diseased nuts.	Fallen nuts.	May 1908.	Healthy.
1	1	431	7	11	0	0	17	2	0	21	2	0	20	3
2	1	431	7	11	0	0	17	3	1	21	3	3	2	1
3	1	431	8	11	0	0	17	5	1	21	7	1	2	0
4	1	431	21	11	0	0	17	7	2	21	13	4	20	0
5	1	431	punctured	-------	branch	---	-------	----	----	21	positive	----	----	----
6	1	203	6	14	0	0	21	3	1	25	2	3	20	1
7	1	203	10	14	0	0	17	2	1	21	3	3	20	0
8	1	203	7	14	0	0	17	1	2	25	1	2	20	1
9	1	203	punctured	-------	branch	---	-------	----	----	21	positive	----	----	----
10	2	203	23	14	0	0	17	0	4	25	5	10	20	1
11	2	203	9	14	0	0	21	0	3	25	0	5	20	2
12	2	203	13	8	0	0	21	2	0	25	1	3	20	10
13	2	203	punctured	-------	branch	---	-------	----	----	25	positive	----	----	----
25	10	220	10	17	1	0	21	2	0	25	5	3	25	0
33	14	444	8	25	0	4	5-2	0	6	5-29	0	1	20	1
34	14	444	11	25	1	7	5-2	3	7	5-20	4	7	20	0
35	14	297	10	21	0	0	4-25	1	4	5-2	4	4	20	2
36	17	462	5	25	0	0	5-2	2	0	5-20	2	1	20	3
37	17	462	19	25	0	9	5-2	5	12	-------	----------	----	----	----
38	17	462	12	25	2	4	5-5	6	6	-------	----------	----	20	0
39	17	462	punctured	-------	twig	---	-------	----	----	4-25	positive	----	----	----
50	21	462	13 large	25	0	2	5-2	0	2	5-20	7	5	20	1
51	21	462	12 large	25	0	0	5-2	0	6	5-20	4	8	20	0
53	21	462	22	25	4	4	5-2	1	14	5-20	5	15	20	2
64	28	462	6	5-5	0	1	5-20	4	1	-------	----------	----	10	1
65	28	2	8	5-5	0	0	5-20	2	1	5-20	2	1	20	5
Totals	----	-----	247	------	8	31	-------	51	74	-------	70	79	----	34

Atomizing on Early Tree.—The preceding table shows the results from inoculation by atomizing of small nuts on a very early blooming

tree. The season of blooming for 1908 was about three weeks later than that of 1907. During the period that this experiment was taking place there was no natural infection developing on the nuts of this tree or in the orchard. The climatic conditions were decidedly unfavorable for blight development. From these inoculations a fair percentage of the nuts became diseased, while from those that dropped no accurate data was secured.

It should be remembered that the season of 1908 was one in which the nuts were practically free from blight, and yet from our atomizing experiments the blight could be produced when the germs were placed on the nuts, although the percentage was somewhat less than that of 1907, because of the less favorable conditions. The small amount of blight for 1908 was due largely to a lack of foggy weather, which is one of the chief ways in which the germs are distributed to the nuts from the old natural sources of infection on the branches.

Table showing source of culture and tests of puncture inoculation on young shoots.

Number of culture.	Date of isolation.	Source of isolation.	Date puncture inoculations.	Results.	Date of observation.	Remarks.
13	06	Unknown	4- 2-08	Positive	4- 4-08	Cultured two years.
33C	1- 3-07	Pith	2-22-08	Positive	4-24-07	
36C	1- 3-07	Pith	2-22-08	Positive	4-24-07	
86B	2- 6-07	Wood and bark	3-19-07	Positive	5-10-07	
92A	2- 6-07	Bark	4- 2-08	Positive	4-25-08	Cultured one year.
97A	2- 9-07	Wood	3-27-07	Positive	5-30-07	
133B	2-22-07	Inner bark	4-11-07	Positive	5-30-07	
144A	2-27-07	Wood and bark	4-24-07	Positive	5-27-07	
145A	2-27-07	Wood	4- 2-07	Positive	5- 9-07	
186A	3-14-07	New growth	4-16-07	Positive	5- 9-07	
202B	3-27-07	Small nuts	4-16-07	Positive	5- 9-07	
203B	3-27-07	Small nuts	4-16-07	Positive	5- 9-07	
203B	3-27-07	Small nuts	4- 1-08	Positive	4-11-08	Year-old culture.
220A	4- 2-07	Small nuts	4-27-07	Positive	5-16-07	
289A	5-17-07	White substance on surface of lesion.				Positive atomizing experiments.
290A	5-17-07	Twig	6- 8-07	Positive	6-19-07	
323A	10-25-07	Wood and bark	4- 2-08	Positive	4-25-08	Fine results.
325B	10-25-07	Bark	4- 2-08	Positive	4-25-08	
335A	11- 5-07	Pith	5-11-08	Doubtful	6- 1-08	
344B	11-16-07	Bark	4- 2-08	Positive	4-11-08	
347A	11-16-07	Wood	4- 2-08	Positive	4-11-08	
348B	11-16-07	Wood and bark	4- 2-08	Positive	4-11-08	
363A	12- 3-07	Wood and bark	5- 5-08	Positive	6- 1-08	
366B	12-12-07	Wood and bark	5-20-08	Positive	6- 1-08	
367A	12-12-07	Wood and bark	5- 5-08	Positive	6- 1-08	
371B	12-19-07	Wood and bark	5- 5-08	Positive	6- 1-08	
372C	12-19-07	Wood and bark	5- 5-08	Positive	6- 1-08	
399B	1- 7-08	Nut on tree	5- 5-08	Positive	6- 1-08	
403C	1-16-08	Wood and bark	5-20-08	Positive	6- 1-08	
417A	2- 4-08	Wood	5-20-08	Positive	6- 1-08	
421X	2- 4-08	Nut on tree	5-20-08	Positive	6- 1-08	
431X	2-19-08	Wood and bark	4- 1-08	Positive	4-17-08	Fine results.
435A	2-19-08	Wood and bark	5-20-08	Positive	6- 1-08	Isolation from puncture inoculation 97A.
440B	3- 3-08	Wood and bark	5-20-08	Positive	6- 1-08	
444A	3-12-08	Wood	4-14-08	Positive	5-20-08	
460B	4- 3-08	Bark	5-11-08	Positive	6-20-08	
461A	4- 3-08	Wood and bark	5- 5-08	Positive	6- 1-08	
462A	4- 8-08	New nuts	4-17-08	Positive	4-25-08	Fine results.
465	4-14-08	New nuts	5- 6-08	Positive	5-20-08	
467	4-17-08	New leaves	5- 6-08	Positive	6- 1-08	

Puncture Inoculation.—The puncture experiments shown in the preceding table were on young growing shoots with culture from potato cylinders after three to five days' growth. These experiments give almost uniformly positive results. During the past two seasons many such inoculations were made and a few of these are summarized in the preceding table. Many other cultures of yellow organisms that somewhat resemble the walnut blight growth were also tested, but with negative results. The table shows, furthermore, that cultures isolated from pith, wood, bark, nuts and leaves all produced the typical blight lesions. In several instances cultures that had been grown on artificial media one and two years gave positive results from puncture inoculations.

MORE DETAILED ACCOUNT OF INOCULATION EXPERIMENTS.

The following description gives more detail regarding certain of the more suggestive experiments:

1. *Puncturing of Nuts.*—April 2, 1907, seven young nuts were inoculated by puncture with a sterilized needle carrying germs from a pure culture of walnut blight. April 12th five of the nuts were still attached, and all showed infection at every place where punctured.

2. *Contact Inoculation.*—April 2, 1907, six small nuts were inculated by simply placing the sticky bacterial growth from a pure potato culture in contact with the nuts without making a puncture of any kind. April 12th four of the nuts were still attached and showed positive infection at points of inoculation.

3. *Atomizing Nuts.*—From culture isolated about six months previously and cultivated during the meantime in artificial media. April 12, 1907, 5 p. m., eight small nuts were atomized with culture from potato, eight days' growth. The day had been cloudy most of the time and was still cloudy when the experiment was made. April 30th six nuts were attached, three of them healthy and three diseased at one or two points. May 9th six nuts were attached and four of them had one or two points of infection. A shoot inoculated at the same time by puncture showed positive infection.

4. *Atomizing nuts from culture of blight isolated from diseased new growth.*—April 16, 1907, six small nuts were atomized with six days' growth of organism on potato cylinders. This culture was originally isolated from blight on new growth. May 9, 1907, the six nuts were still attached and showed fine positive results with many points of infection. Is the use of a culture recently made from blight on new growth the cause of so fine positive results?

5. *Atomizing nut by using solution of water and diseased tissue.*—April 27, 1907, six small nuts on a late blossoming tree were atomized

by using a solution of water and diseased nuts. May 21st six nuts were attached and four of these were diseased, each on one to four places. Other nuts on the tree were free from blight.

6. *Atomizing at Various Hours of the Day.*—June 8, 1907, small nuts were atomized at different periods, 9 to 10 a. m., 5 to 6 p. m. The results are tabulated in the following table:

June 8, 1907.	Number atomized.	Results June 14.		Results June 19.		Results June 24.		Remarks.
		+	—	+	—	+	—	
9:00 a.m.	6 nuts	--	--	0	6	6	0	
9:10	7 nuts	1	5	3	3	6	0	1 nut dropped.
9:25	5 nuts	0	5	1	5	5	0	
9:35	12 nuts	--	--	--	--	5	0	7 nuts dropped.
9:56	7 nuts	1	6	--	--	7	0	
4:20 p.m.	10 nuts	0	10	5	5	10	0	
4:25	5 nuts	0	5	0	5	4	0	1 nut dropped.
4:35	5 nuts	--	--	2	3	4	1	
5:20	4 nuts	0	4	0	4	4	0	
5:35	9 nuts	0	8	0	8	8	0	1 nut dropped.
5:50	6 nuts	0	6	1	5	6	0	
Totals---	76 nuts	2	49	12	44	65	1	10 nuts dropped.

The results from experiment 6 show no difference in the infecting power of the organism for the different hours of the day. The day was bright, sunny and warm. Another interesting fact was that the orchard was being irrigated at the time the atomizing inoculations were made. The ground continued to be wet for about a week after the experiment was made, and the results were exceptionally fine, as all the inoculations showed many points of infection. The nuts treated, with hardly an exception, were all badly blighted with hundreds of points of infection. The extreme virulence of the infections are probably because of favorable external conditions, due without doubt to the additional moisture in the air from the evaporation of the irrigation water. On this tree, as well as on trees in orchard not treated, no additional development of blight occurred, and it is not probable that irrigation in any way increases the amount of blight in an orchard, as at the time walnut orchards are irrigated the conditions necessary for carrying the germs from the sources of infection are usually lacking. From our field observations we have never associated in any way an increase of blight with orchard irrigation.

7. *July 2 and 3, 1907.*—Atomized twenty-six nuts of different sizes, as follows: 5 nuts $1\frac{1}{4}$ inch diameter, 13 nuts $1\frac{1}{2}$ inch diameter, 8 nuts $1\frac{3}{4}$ inch diameter. The weather at this time was very bright and hot, as it was for several days following. The temperature was about 100° F. during the middle of the day. The atomizing was, however, done between 5 and 5:30 p. m., when it was somewhat cooler. The results on July 16th showed 5 of the $1\frac{3}{4}$ inch diameter nuts to be negative and 3

positive, 10 of the 1½ inch diameter nuts negative and 3 positive, and 3 of the 1¼ inch diameter nuts negative and 2 positive. August 1st, however, showed all of the 26 nuts to be more or less diseased. The smaller nuts were covered with many different points of infection, while the larger nuts had a much smaller number of diseased places, usually about twelve on each.

8. The following table shows that there was very slight infection in the afternoon, when the sun was shining brightly and the spray from the atomizer evaporated rapidly. The influence of the bright sunlight would also kill many of the organisms in the liquid atomized on the nuts. The nuts that were infected from the afternoon atomizing had very few places of infection as compared with those of the early forenoon. The atomizing in the early forenoon produced a large number of infections one month after inoculation; those atomized in the afternoon showed a very small percentage of infection as well as few points of infection:

July 13, 1907.	Number atomized.	Results July 23.		Results August 14.		Infection points on each nut.
		Positive.	Negative.	Positive.	Negative.	
7:20 a.m.	8 nuts	0	7	6	0	10 to 50.
7:30	3 nuts	0	3	0	3	Negative results.
7:35	3 nuts	0	3	3	0	
7:45	10 nuts	0	10	10	0	5 to 100.
7:50	2 nuts	0	2	1	1	Diseased at }
8:00	15 nuts	1	14	5	10	10 to 20. }
3:00 p.m.	4 nuts	0	5	1	2	1 spot.
3:20	4 nuts	0	4	1	3	1 spot.
3:25	5 nuts	0	5	1	4	3 spots.
3:30	3 nuts	0	3	0	3	
3:40	7 nuts	0	7	0	7	

INOCULATIONS ON OTHER SPECIES OF JUGLANS.

Puncture inoculations were tried on the several species of *Juglans* that were available. These trees were not of an age to produce nuts, so little atomizing was done. Experiments were made on the eastern black, *Juglans nigra;* on the northern California black, *Juglans hindsii;* on the southern California black, *Juglans californica;* on butternut, *Juglans cinerea;* on Japanese walnuts, *Juglans cordiformis* and *sieboldiana.* Besides these experiments, others were made on several hybrids. Paradox hybrid, a cross between the English and the California black walnut; the Royal hybrid, a cross between the eastern and California black.

Eastern Black.—These were seedlings that had grown two years in our nursery from Iowa black walnuts. Last season's growth had been cut off in grafting and vigorous-growing sprouts had come up from the roots. Inoculations were from pure cultures on these vigorous-growing sprouts. No difficulty was found in producing the typical disease lesions.

Northern California Black.—These were seedling trees growing in our station nursery. Vigorous, fast-growing sprouts from roots that had been grafted were inoculated by puncture and gave definite positive results. One observation is worthy of mention. In a single case the walnut bacteriosis was observed to have spread from one of the positive puncture inoculations to the nearby leaves of the tree. On these leaves typical black spots appeared on the soft tissue of the leaf, as well as on the veins, which were blackened. The black areas of the leaf appeared to be quite characteristic and somewhat different from the effect on the English walnut, in that the black, diseased and partially dried-out tissue was surrounded by a narrow, yellowish-green zone just between the dried-out and healthy tissue. Artificial cultures were made by plating out directly from the diseased tissue and gave yellow colonies which produced the characteristic growth on potato cylinders.

Southern California Black.—A single tree about five years old was first used in this experiment work. Nuts were atomized in the same way as with English walnuts and gave positive results. May 11, 1909, nine nuts were atomized with a water solution of the walnut organism that had grown on potato for six days. May 18, 1909, three nuts showed positive infection and six negative. Later observations did not show further infection on the other atomized nuts. Puncture inoculations on nuts and shoots were also made. The punctured nuts often gave positive results, but inoculations on the shoots of this tree gave negative results. This may be accounted for because of the woody, hard growth. Later puncture experiments on young southern California black seedlings gave fine positive results and there can be no doubt as to the organism being able to infect the southern variety.

Butternut.—Puncture experiment on a two-year-old seedling gave fine positive results.

Japanese Walnut.—*J. cordiformis* and *J. sieboldiana* were inoculated by puncture, but gave rather uncertain results. Positive inoculations were produced in a few cases, but usually the lesion formed did not appear typical, being simply a depressed, blackish spot without the usual water-soaked zone surrounding the puncture. These later healed up readily and would seem to show negative results. Results on these two species are not as conclusive as could be desired, but we believe that on young, vigorous, succulent growth infection could be produced.

Hybrids.—Fine positive puncture inoculations were produced on the Royal Hybrid, the Paradox and Strong Hybrid (a local Paradox Hybrid). These hybrids are vigorous in growth and the disease develôps fully as well as on either of the blacks or the English walnut.

Walnut blight was found during the spring of 1909 on the nuts of a

Paradox Hybrid and typical cultures were obtained from the diseased nuts. Probably all species of *Juglans* can be made to take the disease, although it has not been found in nature on either the eastern or California black. Even the black seedlings in the nursery, where the disease usually appears, are free from the trouble. Blight infection occurs not uncommonly on hybrids.

Pecan seedlings were also inoculated very thoroughly to see if it would be possible to produce the blight by using pure cultures of the walnut organism. Only negative results were obtained.

Desiccation.—Several experiments were made to test out the effect of drying or desiccation on the walnut organism.

Methods.—The general method of testing out the resistance of the organism was as follows:

First a tube of Dunham solution or other liquid medium was inoculated from a pure culture and after a faint cloudiness, was visible usually after twenty-four hours, a loopful of this growth was placed on half inch cover glasses that had been sterilized in a petri dish. These were kept in darkness and tested out by dropping them in tubes of sterilized liquid media and if growth took place, dilution plates were poured and transfers made from them to potato cylinders. If the characteristic, vigorous, piled-up, yellow growth occurs here there is little doubt of its being that of the walnut bacteriosis. In some of the last of our desiccation work it was found to be necessary to make dilution cultures from the tubes which had been inoculated with the desiccated cover glasses, in order to be positive that the growth was due to that of the walnut blight organism. In this work transfers were made directly to potato cylinders from these inoculated tubes. The growth on potato is the most conclusive single test by which to identify this organism.

Experiment I.—November 5, 1908, 3 p. m. Sterile cover glasses were inoculated with a two-millimeter loopful of a 22-hour culture made by inoculating a tube of Dunham solution. These cover glasses were kept in darkness at 20° C. and tested out as indicated in the following table:

Time of desiccation.	Number tubes.	Date of inoculation media.	Date of planting.	Result.	Date of observation.
1 day	9	11- 6-08	11- 9-08	8 tubes show blight	11-18-08
2 days	8	11- 7-08	11-10-08	7 tubes show blight	11-18-08
3 days	9	11- 8-08	11-10-08	0 tubes show blight	11-18-08
4 days	9	11- 9-08	11-13-08	1 tube shows blight	11-30-08
6 days	9	11-11-08	11-18-08	3 tubes show blight	12-10-08
8 days	10	11-13-08	11-18-08	3 tubes show blight	12-15-08

Experiment II.—Made further test of resistance to desiccation on December 18, 1908, under similar conditions to those indicated under *Experiment I.* The following table shows tabulated results:

Day of desiccation.	Number tubes.	Date of testing covers.	Date of planting.	Number with growth.	Number with walnut blight.	Date of observation.
3 days	10	12-21-08	12-26-08	2 tubes with growth	2 show blight	1-12-09
5 days	14	12-23-08	12-30-08	2 tubes with growth	2 show blight	1-12-09
7 days	17	12-25-08	12-31-08	3 tubes with growth	1 show blight	1-12-09
8 days	10	12-26-08	12-31-08	1 tube with growth	1 show blight	1-12-09
10 days	13	12-28-08	1- 4-09	1 tube with growth	1 show blight	1-12-09
12 days	20	12-30-08	1- 4-09	2 tubes with growth	1 show blight	1-12-09
20 days	14	1- 7-09	1-12-09	4 tubes with growth	4 show blight	1-21-09
29 days	13	1-16-09	1-20-09	3 tubes with growth	0 show blight	1-15-09

The experiment showed very few tubes with the blight organism alive even after three days, but some of the tubes show growth of the organism even after twenty days.

Experiment III.—January 2, 1911. Used a three-day-old culture growing in a meat peptone glucose bouillon made as follows: 5 gm. Liebig meat extract, 5 gm. NaCl, 10 gm. Witte's peptone, 1,000 c.c. distilled water, 5 gm. glucose (Merck). This same medium was also used in which to test the desiccated cover glasses. A loopful of culture was placed on each sterilized one half inch cover glass, using a 2 mm. loop on the platinum needle. These covers were dropped into the above medium at given intervals of time, as is shown in the following table:

Date of inoculation.	Number tubes.	Number days desiccation.	Results.
January 1, 1911	5	3 days	4 tubes with walnut bacteriosis
January 9, 1911	10	7 days	5 tubes with walnut bacteriosis
January 12, 1911	10	10 days	10 tubes with walnut bacteriosis
January 17, 1911	10	15 days	10 tubes with walnut bacteriosis
January 20, 1911	10	18 days	10 tubes with walnut bacteriosis
January 25, 1911	10	23 days	8 tubes with walnut bacteriosis
February 10, 1911	11	39 days	7 tubes with walnut bacteriosis
March 1, 1911	10	57 days	4 tubes with walnut bacteriosis
March 16, 1911	10	73 days	1 tube with walnut bacteriosis

The inoculated tubes were incubated at 20° to 25° C., as well as the inoculated potato cylinders. The desiccating cover glasses were kept at about 15° C. This organism belongs to a genus in which are several yellow chromogenic organisms that are quite resistant to drying.

Experiment IV.—This experiment was a combination of desiccation and influence of light. March 9, 1908, a tube of Dunham solution was inoculated. After three days' growth at 20° C. this liquid was atomized on living olive shoots about one year old.

Series 1. The same liquid was atomized on a small English walnut

tree one year old that had been cut off. The bark, however, was still green and had not dried out at the time of the experiment.

Series 2. Pieces of the atomized bark were then cut out from time to time and dropped into the test tubes of nutrient media, in the same way that cover glasses were used in the other desiccation experiments.

Series I.

Number days drying.	Number tubes.	Positive.	Negative.
1 day	3	2	1
2 days	3	1	2
3 days	3	1	2
4 days	3	2	1
17 days	3	0	3

Series II.

1 day	3	2	1
2 days	3	1	2
4 days	3	2	1
17 days	3	0	3

Growths in the inoculated tubes were plated out and transfers of yellow colonies were made to potato cylinders. The characteristic growth on this medium was taken to be conclusive evidence that the growth was that of the walnut bacteriosis organism.

ACTION OF GERMICIDES ON THE WALNUT ORGANISM.

Considerable work has been done in experimenting upon the effectiveness of various germicides in killing the walnut organism. Copper sulphate, mercuric chloride, formalin, potassium permanganate and sodium benzoate were used in this work.

Method.—The following method was employed in testing the killing of organism:

A pure culture of the walnut blight organism was grown for twenty to forty-eight hours in Dunham solution. The culture tubes at this time were considerably clouded with growth. Then three loopfuls of the culture were transferred with a 2 mm. loop to tubes containing the germicide under experimentation. The germicide was always made up with distilled water and of several different strengths. In each tube there was a definite amount of the germicide, either 5 or 10 c.c. In all cases, except formalin, the tubes were sterilized on three successive days for twenty minutes.

Copper Sulphate.—In this experiment the commercial copper sulphate was used with distilled water. The following strengths were tested: 1/10 per cent, 1/100 per cent, 1/500 per cent, 1/1000 per cent, 1/2500 per cent. 1/5000 per cent.

Each of the tubes to be tested had 5 c.c. of the copper sulphate solution and was sterilized on three successive days. There were three tubes of each of the preceding dilutions as well as three check tubes of distilled water. Each of the tubes was inoculated with three loopfuls of a walnut blight culture grown in Dunham solution for forty-eight hours. The loop of needle was 2 mm. in diameter. Three hours after being inoculated dilution plates were made from each of the tubes under experiment by transferring three loopfuls of the inoculated germicidal tube to meat peptone agar. These plates constituted series I of the experiment. After six hours from inoculation of tubes containing the germicide a second plating out from the tubes was made in the same manner as the first.

The results after seven days' growth in the Petri plates showed that no growth resulted in the plates of series I made from 1/100 per cent, 1/500 per cent, 1/1000 per cent or 1/2500 per cent copper sulphate. In the check tubes as well as in the 1/5000 per cent, a large number of colonies developed.

The three plates made from the 1/5000 per cent had 8, 30 and 60 walnut blight colonies, while the two check plates had 200 and 225 blight colonies, and the third plate had a spreading, white, foreign organism that covered the entire surface of plate and covered up the walnut blight growth.

In series II, plated out after six hours' incubation, no growth occurred during seven days.

Another experiment made earlier in the study gave almost the same results. The 1/100 per cent, 1/500 per cent and 1/1000 per cent killed the organism, while the 1/5000 per cent failed to do so. No test was made of the 1/2500 per cent in this experiment. The per cent of copper sulphate sufficient to kill is somewhere between 1/2500 and 1/5000 per cent.

Mercuric Bichloride (corrosive sublimate).—The same general method was employed as with copper sulphate. Four tubes each of the following strengths were used in distilled water: 1/100 per cent, 1/500 per cent, 1/1000 per cent, 1/5000 per cent, and 1/10000 per cent and two check tubes of distilled water. All were sterilized and then inoculated with four loopfuls of a 24-hour growth of the organism in meat bouillon. In four hours from inoculation, plates were made from each tube. After six days' time no growth developed in any but the check plates and these showed 41, 48 and 150 colonies each.

Another experiment with corrosive sublimate, using more dilute strength in distilled water, was made. Three tubes of each of the following strengths were tested: 1/1000 per cent, 1/10000 per cent, 1/50000 per cent, 1/100000 per cent, 1/500000 per cent, and 1/1000000

per cent. Dilution plates were made after three hours' time, using four loopfuls from each tube to inoculate the agar tubes. In seven days the following results were given: Growth in 1/10000 per cent and the weaker strengths.

Carbolic Acid.—The following per cents were made, using distilled water to properly dilute the 5 per cent stock solution of carbolic acid (Merck): 1/2, 1/4, 1/10, 1/25, 1/50, 1/100 per cents, four tubes of each and three check tubes of distilled water. Tubes were inoculated with three loopfuls of walnut blight culture and dilution plates were made after three hours. After six days 1/2 and 1/4 per cents showed either no growth or at least not walnut blight. The other lower per cents 1/10, 1/25, 1/50, and 1/100 showed some growth. The 1/10 per cent developed 12 and 7 colonies in two of the plates, while the other two showed no growth.

An attempt was at first made to use the carbolic acid with a solution containing peptone, but the results are not exact because there was a precipitate due to the chemical action of the acid with the peptone. A series of tubes containing Dunham solution and carbolic acid was made and the tubes inoculated with three loopfuls from a four days' growth in meat bouillon. Growth and cloudiness of tubes occurred in 1/25, 1/50 and 1/100 per cents. No growth in tubes having 1, 1/2, and 1/4 per cents. Plates were made from the tubes and the results obtained agree with the statements above.

Formalin.—A 1/25 per cent solution acting for three hours on the organism was effective in killing. A solution of 1/50 per cent formalin acting for the same time did not kill.

Potassium Permanganate—A solution of 1/500 per cent acting for three hours killed the organism.

Sodium Benzoate.—This chemical was tested but showed poor germicidal action. A solution of 1 per cent did not kill the organism even after six days' time. This strength was sufficient to inhibit growth of organism when used in Dunham solution, but when plates were made from these tubes colonies of walnut blight developed.

CONTROL OF WALNUT BLIGHT.

Spraying.—The earliest attempts at the control of this disease consisted, as has been the case with most plant diseases, in spraying with Bordeaux mixture. Pierce carried on a considerable amount of such work and at his suggestion a number of growers gave this method of treatment quite a thorough trial. As a result of his work Pierce recommended spraying with Bordeaux mixture just before the trees came

into leaf in the spring, and also a later spraying during the early summer if the latter should be considered necessary or practicable. He likewise urged the removal of all affected twigs and fruit spurs. Professor Pierce stated that by following these recommendations thoroughly it was possible to reduce the number of blighted nuts by fifty per cent. Mr. E. G. Ware, of Garden Grove, while in charge of a large walnut grove near Placentia, which belonged at that time to Thum Brothers, carried on what was probably the most extensive and most carefully conducted experiment along this line. For several years he sprayed thoroughly with Bordeaux mixture, using large blocks of trees and leaving unsprayed trees or rows as checks. Mr. Ware came to practically the same conclusion as Professor Pierce, namely, that the number of blighted nuts could be reduced about 50 per cent by spraying with Bordeaux mixture just as the buds are swelling. Neither of these experimenters was able to state any distinct increase in the crop obtained by spraying, but it should be said that such a measure of results is practically impossible in seedling walnut groves on account of the extreme variation in the production of the various individual trees. Mr. Ware also experimented with the application of lime to the soil after Professor Pierce's suggestion, with the idea that this might produce a firmer, harder tissue in the growth of the trees and thus render them less susceptible to blight. He believed that some benefit was derived from such an application, using large quantities of air-slacked or sugar-beet factory refuse lime. Other growers have sprayed their walnut trees with Bordeaux mixture and various other materials at different times, but it may be said in a general way that such practice has never become common and for several years it has been entirely discontinued.

At the commencement of this work in 1905 plans were made to carry on very thoroughly and systematic spraying experiments in order to determine definitely the extent to which blight control could be accomplished by this means. In the spring of 1906 several large blocks of good sized seedling walnut trees were obtained for this purpose in the vicinity of Whittier and spraying operations were commenced. The principal experiments were made with three different fungicides, Bordeaux mixture, lime-sulphur, and a sulphur spray made by boiling together sulphur and caustic potash. The work was done with a power sprayer, and was carried on more thoroughly and carefully than any grower would be likely to do such spraying and without regard to expense. In one instance a large block of trees was sprayed with Bordeaux mixture, using a 5–6–50 formula, in another a heavy lime-sulphur was used, the spray being prepared by boiling, while in the third the potash-sulphur spray mentioned above was used. It was

found in all this work that to spray large walnut trees thoroughly is an extremely slow, difficult, and expensive operation. In the case of the largest trees no attempt was made to spray more than two thirds of the tree from the bottom up, inasmuch as the top could not be thoroughly covered without using a very high platform. Our experience was that to spray a good sized tree thoroughly or to cover even two thirds of an extra large tree required at least twenty gallons of material. We found further that with the outfit used, consisting of three men to spray and one to mix, not more than fifty good sized trees could be sprayed in one day, while with the largest ones thirty was about the limit of a day's work. It was found further that even when the work was done with apparent thoroughness on these large trees many portions of the top remained unsprayed the first time over. This was detected particularly in spraying with lime-sulphur, where the sprayed and unsprayed portions of the tree showed up in strong contrast as soon as the spray had dried. For this reason it was found necessary with these large trees to go back over them sometimes two or three times in order to be sure that every twig and branch which might harbor blight lesions was covered with the spray. As regards expense, we found that we could not thoroughly spray good sized trees for less than about 50 cents each, counting labor and materials, while with many of the largest trees the outlay amounted to at least $1.00 per tree even though the top of the tree was not sprayed at all. As a result of this experience we were led very soon to believe that the general spraying of California walnut groves for blight control would be extremely difficult of accomplishment during the period of time available for such work, and also that it would be extremely difficult, if not absolutely impossible, for the average grower to get the work done thoroughly enough, even though the spraying done by ourselves should prove extremely effective in controlling the disease.

During the summer following our spraying careful observations were made from time to time of the condition as to blight of the sprayed and unsprayed trees in the experimental orchards. From such observations no difference whatever in the prevalence of the disease on the nuts could be detected. Many of the sprayed trees lost a large portion of their crop from blight, and even on individual, rather small trees or individual branches which had been especially well sprayed and absolutely covered with the mixture much blight developed on the nuts, and it soon became apparent that no satisfactory degree of control, if any, had been secured by our work. In the fall weighings were made of the crop from the various trees and blocks, but owing to the extreme variation in the crop of individual seedling trees the result was the same as in our fertilizer experiment described on page 185, namely that

no conclusions whatever could be drawn. This much, however, was very evident from observation, that a very large amount of blight developed on many of the sprayed trees and that no decided benefit in the season's crop of nuts had been obtained by the spraying. Even where trees or branches had been perfectly and entirely coated with heavy lime-sulphur solution, a large number of blighted nuts appeared.

As a result of our experience in 1906, first with the cost, difficulty, and slowness of spraying large walnut trees, and second with the lack of effect of such spraying, we became thoroughly convinced that the possibilities of walnut blight control did not lie in this direction. Furthermore, as the prospect of obtaining varieties of the walnut more or less immune to the disease, and likewise of much better quality and much greater production than the average seedlings, became brighter and brighter the undesirability of spraying methods became still more pronounced. For these reasons no further extensive spraying experiments were made by us and we still believe that the ultimate control of walnut blight does not lie in this direction. It should be stated, however, that during the following year, that is in 1907, the appearance of the trees sprayed in the spring of 1906 gave some reason to believe that the blight was less prevalent on the sprayed than on the unsprayed trees. This was particularly true in the case of trees sprayed with lime-sulphur. It is, therefore, not improbable that while infection of the nuts during the year when the spraying was done was not prevented, that the twig and shoot infection was somewhat controlled and that on this account less blight was carried over winter and less nut infection took place the following year. It is further possible and quite likely that thorough spraying year after year would have a cumulative effect and might eventually reduce the amount of blight to a noticeable and satisfactory extent. Even if this were true, however, we have not felt that it would be practical to accomplish this to any general extent on account of the reasons mentioned above.

During the past season or two there has been a considerable revival of interest in walnut spraying in one portion of the State, namely, in Santa Barbara and Ventura counties. This has been due to the importance of the walnut industry in that region, the serious prevalence of blight, and to the fact that a certain proprietary remedy or mixture has received considerable prominence in that locality and has been used in a large part of the spraying which has been done there. Walnut spraying having thus become somewhat customary in the counties mentioned, some work has been done there with Bordeaux mixture and various other materials which have suggested themselves to the growers. We do not wish to discourage such attempts at blight control in a region where some of our oldest and finest seedling groves exist, one which is espe-

cially adapted to walnut culture, and where the maintenance of the present groves is of as much or perhaps more importance than the possibilities of planting new ones. The chief problem in walnut blight control by spraying lies, in our opinion, not so much in the discovery of a specific for the disease, since there is no reason why any good fungicide should not be as good as any other for this purpose, but rather in the development of means of spraying these large trees rapidly and economically and at the same time thoroughly. Investigations are still being continued along this line, particularly in coöperation with Mr. C. W. Beers, horticultural commissioner of Santa Barbara County, and a renewal of spray work along new lines and upon a considerable scale is being prepared for.

Blight Control by Means of Applications to the Soil.—Various suggestions and experiments have been made along the line of applying various substances to the soil with the idea of controlling walnut blight by this means. Especially prominent has been the application of lime, mostly beet factory refuse. It is impossible to state definitely just what may have been accomplished by such methods as these, but it is very certain that nothing of this sort has resulted in blight control to an extent at all significant or important. In trees which are suffering for plant food the growth may be stimulated and increased by heavy applications of stable manure or nitrogenous fertilizers, and as a result of this the crop may be increased and the loss by blight lessened. This we believe to be the extent of any good results which may be obtained by the application of any substance to the soil.

Resistant Varieties.—It has been noted ever since walnut blight first became prevalent in California that there is a great difference in individual trees as to the extent to which they are affected by the disease. Some trees regularly lose almost all their nuts by blight, others are noticeably free from it, while others vary from year to year, being badly blighted one year and comparatively free from the disease the next. As a result of such observations the possibility of selecting or producing blight immune varieties was suggested several years ago. Pierce in his work considered this phase of the matter, and brought together a collection of walnut species and varieties from various parts of the world, as well as local selections, with this object. On account, however, of the discontinuance of his walnut work no definite results along this line have ever been announced by Professor Pierce. Various nurserymen have also worked to some extent along the same line, endeavoring to pick out and propagate from individual trees of uniformly large production of nuts. The fact was early established that the extent to which individual trees blight depends with much regularity upon the season at which the trees develop in the spring, trees late in coming out being

freer from blight than those which open their buds earlier in the season. The reason for this difference was easily apparent, being connected with conditions of atmospheric moisture. Trees coming out late escape the spring rains and fogs, which period is by far the worst for blight infection. Some observations seem to indicate that trees coming out unusually early in the spring are also freer from blight than the average, and there appears to be some truth in this fact. If this is correct, it is probable that these early trees escape blight infection owing to the lower temperature which prevails at the time when their shoots and nuts are young and easily susceptible. We have shown elsewhere that the blight organism requires a fairly high temperature for its most vigorous development. These early and late blight-free trees really escape infection therefore, rather than actually resisting it, or rather they escape it at the time when they are most susceptible and then are able to resist any later infection on account of the maturity of their tissues. It is true, however, that certain individual trees have some actual resistance to the disease, even at susceptible periods, and those having such immunity are of course the most desirable type.

In seeking blight-resistant or immune walnut trees there must at the same time be kept in mind the fact that freedom from blight is not the only quality necessary in the walnut, since we must also have a tree of heavy production, with nuts of desirable size, form, color, fullness of meat, flavor and other qualities which go to make up an ideal walnut. The strongest emphasis should also be laid on the fact that the performance of a single tree in a given locality, either as to blight, bearing qualities, or character of the nuts does not justify its exploitation for all parts of California under the widely different conditions which exist in different localities. Freedom from blight in a certain tree or variety in a given locality may be due simply to the fact that the disease is not present or conditions not favorable to its development in that particular place. When planted in another locality the same variety may prove to be one of the very worst affected by blight. Again, a given variety may produce very heavily in one locality under certain climatic conditions and not in another. Again, a tree may be free from blight and produce a very large crop of nuts one year or even for several years, and then later on develop the disease very badly and produce only a very few good nuts. Again, a tree or variety may be actually immune to blight to a large extent and still be a very small producer or produce nuts of an undesirable type in size, form, color, flavor, or some other characteristic. Still again, a variety may have only slight immunity to blight and yet have so much vigor of growth and tendency toward heavy production that the resulting crop, in spite of the blight, will be much larger than that of a more resistant but less productive tree. Still further, one variety may produce very heavy crops of nuts

of only fair quality, while another may be a small producer of extra fancy nuts. All these and other considerations go to show that one cannot be too careful and conservative in recommending and exploiting a variety for general planting on the basis of its immunity to blight or the quality and quantity of its product. Only after several years' experience in any given locality can the qualities of a certain variety be fairly estimated, and even then its behavior in other localities, where conditions are considerably different, cannot be safely foretold without actual trial. Many a walnut grower has bought high-priced trees from a distance on account of enthusiastic advertising and extravagant praise, when there were scores of trees in his own locality which might have been propagated from with much better results than those which he will obtain from his high-priced trees, brought from a distant portion of the State, where the whole reputation of the variety rests perhaps upon the performance of one individual, original tree. We have discussed the various varieties now on the market as fully as possible in another place. If our descriptions and estimations seem to be lacking in positive, definite statements, it may be understood that this is not on account of lack of acquaintance with the varieties mentioned, but is simply due to the fact that they have not been widely tested, and their qualities cannot be positively stated in justice either to the variety or to the public.

The control of walnut blight by means of immune varieties presupposes to a very large extent the planting of new groves in place of the present seedling, irregular, blight-susceptible ones. Many, however, will feel that such a solution of the problem falls far short of complete satisfaction on account of the large acreage of seedling trees now in existence which have cost much effort and expense to produce, which would be fairly profitable were it not for the blight, and which it is a very serious matter, or perhaps almost entirely out of the question, to think of replacing with new trees of better varieties. Especially in Orange, Los Angeles, Ventura, and Santa Barbara counties do such groves exist, and this bulletin would not be complete without a discussion of the future prospects and best methods of handling these seedling groves, composed of large healthy trees in normal, thrifty condition, save for the attacks of blight upon the crop.

Working Over Seedling Groves to Better Varieties.—The situation now confronting the seedling walnut growers of California is not a unique one, inasmuch as the same condition has confronted in turn the growers of the apple, peach, orange, lemon, and all our other cultivated fruits. The seedling orange grove is still with us to a considerable extent, and the seedling apple orchard is still easily within the remembrance of the present generation. It is not, therefore, an unusual situation which the walnut grower has to face, and he may rest assured

that it will eventually result in the entire replacement of the seedling tree by definite varieties propagated by grafting or budding. In our most familiar instance, that of the orange, the problem of what to do with the thrifty old seedling grove has been easily solved by top-working these trees to better varieties. With the orange and other citrus fruits this is a comparatively easy operation. With the walnut, however, it is by no means as simple and yet not at all impossible. A few growers, notably one, have attacked the problem in this way with very excellent results. Mr. J. B. Neff, of Anaheim, who had an old walnut grove planted as seedling trees, commenced a systematic effort several years ago of improving his trees by top-working. For several years he observed the grove carefully, picking out the poorest-producing and most blight-susceptible trees, and also one tree which seemed by far the heaviest producer and least affected by blight of any in the orchard. Having located his very poorest trees and the best one, he commenced operations by cutting off the tops of the poor trees just above the main forks and top-grafting them with scions from the good tree. The success of the first year's grafting was very good, although some misses occurred which had to be worked over again the next year. During the second year more trees were cut off and worked, and with the working over of the previous year's misses the whole work extended over three or four years before the grove reached a condition satisfactory to the owner. The ultimate outcome has been, however, that the average quality and productiveness of trees were very much increased, and after about four or five years practically all the grafted trees have as large tops as those which had not been top-worked. As to the effect of this work upon the production of the grove, Mr. Neff states that he does not think that the cutting off of the poorest trees diminished his total crop after the first year. One eighth of all the trees in the orchard were top-grafted the first year and one fourth of the total trees the second year, making altogether three eighths of the trees which were cut off and worked over. The total number of trees cut off and grafted was about 200. In 1907, the year previous to the first grafting, the total crop was 20,406 pounds. The grafting was done in 1908 and 1909. In 1911 the total crop was 26,297 pounds. During the intervening years the crop was smaller than in either 1907 or 1911, varying considerably along with the walnut production at large in southern California.

Mr. C. B. Franklin of Carpinteria has also done considerable work along this line, working over his poorest trees into better kinds. At the Pasadena City Farm, near Alhambra, a large number of seedling trees about six years of age have been worked over into various varieties, in this case top-grafting a whole row or a solid block of trees at one time rather than picking out the poorest ones. The work here was quite uniformly successful at the first attempt and very little regrafting

has been necessary. Various other growers have top-worked a greater or less number of orchard trees with varying success. The whole matter rests largely upon the skill of the operator who does the grafting and the care and attention given to the trees after grafting until the new tops are well established. Men who are able to top-graft the walnut with fairly uniform success are decidedly uncommon and yet there is no particular mystery or secret about the operation. It depends entirely upon mechanical skill in this sort of work, knowledge and judgment of the peculiarities of the walnut tree, and particularly upon great care, thoroughness and attention to details in selecting and keeping the scions, doing the grafting, and the subsequent care of the grafts, especially during the first season. Unless prepared to give the work this special care and attention until new tops are well established upon the trees we would not advise any grower to attempt to improve his walnut grove by top-working. If, however, he can give the work such attention, either in person or through reliable, competent help, we would strongly advise any grower to follow Mr. Neff's example, pick out his poorest trees and work them over into a better variety, either by selecting scions from an especially good tree in the immediate neighborhood or by putting in some good variety among those which we describe elsewhere. Again, however, we would emphasize the fact that if the grower cannot undertake this work with the assurance of giving it careful, continuous attention, he would much better leave his grove in its present condition, since otherwise he will find himself with a lot of trees composed of a mass of sprouts coming from the cut-off branches, the latter decaying and dying back in the stubs where they were cut, leaving the grove in much worse condition than before.

Other than top-grafting, the only method of bringing about improvement in a seedling grove is by means of more regular and abundant irrigation, pruning and thinning out the tops if they are too thick, heavy fertilization with stable manure or nitrogenous fertilizers, and such other improvements in cultural practice as may suggest themselves. These matters we have discussed on pages 182–192.

The problem of the seedling walnut grove is being readily solved in many portions of southern California by the rapidly increasing value of land and the prosperous condition of the citrus industry. Many hundreds of acres of thrifty seedling walnut trees have been cut out in Los Angeles and Orange, and, to some extent, in Ventura County, during the past few years, and planted to citrus fruits, especially lemons. At the high valuation now placed upon the best land in these counties, it is doubtful if any present variety of walnut could compete with the lemon or Valencia orange, and the walnut acreage is very rapidly being transformed into citrus groves. This tendency becomes more and more pronounced every year.

DIE-BACK.

The most conspicuous disease or trouble affecting walnuts in southern California is that characterized by this name. Two general types of die-

FIG. 90.—Die-Back, caused by dry soil and cold weather.

back may be distinguished, one on old trees, particularly hard shells, which die back slowly all over the top, and another occurring suddenly during a single winter in all or part of the limbs, which may die back

down to the main forks of the tree or the tree may die outright clear to the ground. The former type of die-back, affecting old trees slowly, occurs mostly on light soils where the roots find insufficient moisture as they become crowded together and extend down into a dry, sandy subsoil. The second form of die-back mentioned, that occurring in trees which have formerly been thrifty, killing them down to the forks or even to the ground, is sometimes an effect of frost, but occurs especially with or without freezing in cases where the ground has become too dry during the fall and winter. This is of quite common occurrence in walnut groves, especially in certain seasons when the rainfall is deficient during the fall and early winter. At this time of year irrigation of dormant deciduous trees does not seem to be urgent and serious damage sometimes occurs. In a cold locality or season this damage may be very much increased by frost, when, if the soil had been sufficiently moist, no die-back would have occurred. The remedy is therefore obvious, and it is significant that fall and winter irrigation of walnut groves is coming much more into practice every year. It may be said in general that almost all die-back of walnut trees is connected with the matter of soil moisture. Usually it is the direct result of a dry subsoil, although in old, closely planted groves the trouble may be increased by a lack of proper distance between the trees, deficiency of plant food, and similar factors.

Instances are sometimes seen when the opposite condition prevails, die-back being caused by an excess of moisture in the subsoil, a condition of which the walnut tree is extremely intolerant. Such damage may be seen to a marked extent in some of the coastward regions of Ventura County and in other parts of the State, where, on account of floods or other unusual conditions, the ground water has risen in walnut groves close to the surface.

SUNBURN—BLACK SAP.

Serious damage is sometimes caused from this source, both to the fruit and the tree. This we have already discussed to some extent on page 177, in considering the relation of climatic conditions to walnut culture. The sudden occurrence of extremely hot, sunny weather when the nuts are nearly full grown may produce a blackening and burning of the husk on one side, causing the husk to stick to the shell, making separation difficult and causing a black spot which may extend through into the meat. Continuous hot weather may cause a darkening or brownish color of the meat which would otherwise be nearly white, without a burning of the outer husk. This varies to a large extent in different varieties.

FIG. 91.—Sunburn or "black-sap" on trunk.

On the tree itself the trunk is frequently affected by sunburn, causing on large trunks a condition frequently called by the growers "black sap." This consists of a considerable area on the south or southwest side of the trunk where the inner bark is dead and from which the sap of the tree oozes out, oxidizing and turning black, as is the habit of walnut sap whenever exposed to the air. This form of sunburn occurs more commonly in the winter rather than in the summer, and takes place at times when the days are hot and the nights are cold. These conditions produce an irregular activity of the sap, which causes the trunk to be especially susceptible to the heat of the sun. The cambium is killed, usually on the southwest side of the trunk, and the sap then escapes, oxidizes and ferments in the affected area and a large wound may result in which ordinary

Fig. 92.—Sunburn on nuts.

decay sets in. It is on account of this form of sunburn that high grafting on black walnut stock is advocated in order to obtain the rough-barked trunk of the black walnut. We have seen cases, however, when even the latter was affected by this form of sunburn. Young trees during their first year after planting in the orchard often become badly sunburned in the trunk and on this account should be protected after planting, as discussed on page 253. For the same reason it is better to cut the trees well back before planting and grow a new stem from one of the lower buds, as described on page 251. The whole matter of sunburn, either on the fruit or the wood, is influenced to a very large extent by the moisture conditions of the soil. In all cases trees with an abundant moisture supply, and especially if in fairly heavy soil of good water-retaining properties, are much less affected by any form of sunburn, either summer or winter, than those which are suffering for water.

PERFORATION.

This has come to be one of the most serious troubles of the walnut grower during recent years. The effect is that shown in Fig. 93 and consists in a non-development of the outer hard layer of the shell. The meat or seed of the walnut is covered normally by four different layers of tissue. The first of these is the pellicle or seed coat, the thin membrane just over the meat which adheres closely to it and follows

FIG. 93.—"Perforation" of walnuts.

all the convolutions and irregularities of its shape. Outside of this is what we call the shell, which consists of two distinct layers, a thin, inner, parchment-like one, forming the lining of the shell, and a hard, bony outer layer. The fourth coating mentioned is composed of the husk on the outside of the nut which opens and allows the nut to fall out at maturity. In perforated nuts the hard shell is not actually perforated, but rather fails to develop. In such nuts the meat and pellicle develop normally and over them the thin, inner lining of the shell.

The hard, outer shell is deficient and fails to develop properly. This failure, or in other words the cause of perforation, is not thoroughly understood, but is probably connected with one of two factors, or possibly both. These are, the fertilization or pollination of the nut during the blooming period and its nutrition during development. Perforation has been especially abundant under two conditions: first, in unusually dry years, especially when the trees were badly affected with the walnut aphis; second, in young trees which are making a particularly thrifty growth. The trouble also varies to a considerable extent in individual trees, some being affected every year and others never showing this trouble. In some instances there has been some indication that the trouble was worse in years when pollination was interfered with, either by extremely dry weather or frost during the blooming period. This, however, is not well established. It seems most probable that the disease is due to lack of nutrition of the nuts due to dryness of the soil, exhaustion of the trees by aphis attacks, or, in the case of young trees, a vigorous development of wood at the expense of the nuts. If this be true it may be expected in the case of young trees that they will gradually outgrow the trouble as they become older and divert their energies more toward crop production, while in the case of older trees abundant irrigation throughout the year and the control of aphis (which we discuss elsewhere) offers most promise in the prevention of perforation.

CROWN GALL.

This disease which is common in most fruit trees does not often affect the walnut seriously, although now and then a badly affected tree like that shown in Fig. 94 may be found. The trouble manifests itself as a large swelling or gall at the base of the trunk either just above or just below ground or both. It is caused by a bacterial organism of a decidedly parasitic, infectious nature.

Occasionally a nursery tree is found affected with this disease, although it is very much less common in the walnut than in the peach, apricot, almond, apple and other trees. It has generally been supposed that only the English walnut root is susceptible to crown gall, but we have recently seen a case of a northern California black walnut root badly affected with this trouble. This, however, is decidedly uncommon. Any nursery tree which shows this trouble should be discarded. Trees affected in the orchard show a failure of growth, gradually falling behind the other trees in size, and should be dug out and replaced as soon as detected. The galls may be chiseled out

and disinfected with some success, but the trouble cannot be entirely overcome in this way. Usually decay sets in, as shown in the illustration, and the tree eventually breaks off.

FIG. 94.—Crown gall.

ROOT ROT.

(OAK FUNGUS—TOADSTOOL DISEASE.)

The English walnut root is quite susceptible to the so-called oak fungus or toadstool disease, which occasions the loss of many fruit trees of various kinds in California. This disease consists in a decay of the roots, in which the white mycelium of the fungus may be found between the affected bark and wood. Occasional clusters of toadstools appear at the base of affected trees. The disease usually, if not always, occurs in spots where oak trees formerly stood and when once started spreads from tree to tree in quite a regular concentric manner. Experience has amply demonstrated that our native black walnut roots are immune to this fungus and we have seen cases where English walnut, prune, almond and other roots have been picked out and killed, while northern California black walnuts interplanted with these trees remained entirely unaffected. It is altogether probable that all of our black walnut species and hybrids are highly resistant if not totally immune to this disease.

SEEDLING ROOT ROT—WILT.

Nursery seedlings of the southern California black walnut occasionally wilt and die rather suddenly and show, on examination, a black rot of the main root just below ground. This may appear either before or after grafting, and ordinarily, at the worst, picks out only a tree or two here and there, even in a large nursery. We have known of only one case where serious loss was experienced from this source, and this on poorly drained land where the trees were injured by an excess of water. The trouble is caused by a soil fungus, and seems to be confined to the southern California black.

LITTLE LEAF, "YELLOWS."

In this disease spindling yellow shoots develop wihch usually die back from the top. All degrees of the trouble may occur from slightly unnatural yellowing and slenderness of the normal shoots to the production of abnormal clusters of small, yellow, sickly shoots with very slender, yellow, poorly developed leaflets. Such shoots in bad cases usually die back at the end of each season. This disease affects the English walnut and is even more pronounced on the northern California black in certain seasons and places. It has been abundant even on black walnut trees of large size in some parts of northern California during the last two or three years and very prevalent in nursery trees of the northern California species grown in the southern part of the State. The southern California black walnut is, so far as our experience goes, immune to this disease, while the Paradox and Royal hybrids, especially the latter, are much less susceptible to it than either the English or northern California black. This disease is not confined to the walnut but is evidently the same as the so-called "Little Leaf" of the grape, peach, apple, quince and umbrella tree, and the mottled leaf of the orange. The "Frizzles" or "Rosette" of the pecan seems also to be of a similar nature. Experience has shown beyond any reasonable doubt that the occurrence of all these troubles has been the result of the abnormally long dry seasons of the past three years. These diseases have occurred particularly, or in fact altogether, on soils where for any reason the subsoil has become very dry during the latter part of the season. Such condition has been most commonly caused by sandy or gravelly subsoil but may also result from the presence of hardpan or a layer of heavy soil within two or three feet of the surface. The control of this trouble lies entirely in irrigation, especially in the late summer and fall during seasons when the rains are late in commencing.

If the soil is kept well watered during this period this disease need not be feared. In the case of hardpan or heavy soil underlaid by dry subsoil some growers have resorted to the practice of blasting with

FIG. 95.—Little leaf or yellows; on northern California black above, on English at the left below. Normal branch at the right.

dynamite in order to let the water down through into the subsoil. We believe this to be an excellent method of procedure. The most important factor in the prevention or avoidance of little leaf lies in the choice

of a root for the walnut. Also the selection of soil upon which to plant this crop. Land having a sandy or gravelly subsoil within four or five feet of the surface should, if possible, be strictly avoided for planting a walnut orchard. The same is true of soil underlaid by hardpan. In any case it is very desirable to blast each hole with

Fig. 96.—Placentia walnut tree on English root, affected by yellows. Trees like that shown in Fig. 63, on southern California black root, are of same age and interplanted alternately with these.

dynamite before planting in order that the subsoil may be shaken up and easy access of water permitted. No tree already affected with this disease should be grafted, either in the nursery or in the case of black walnut trees planted in orchard form. The pervalence of this trouble is another argument in favor of the hybrid root or the southern

California black, the latter at least in the southern part of the State, or for varieties which come out early in the spring. A very good illustration of the difference in respect to this disease produced by different roots was seen in a walnut orchard near Whittier during the past season. In this case trees of the Placentia Perfection variety had been double planted, the permanent trees on southern black root and the fillers on English. During the latter part of the season of 1911 the difference between the trees on the two roots was very marked, those on the English being smaller, with yellow foliage and narrow leaflets, the leaves falling to the ground early in the fall. The alternate trees on southern California black root were larger, bore a better crop and had dark green, vigorous looking foliage which remained on the trees much later than that of the other trees.

SHRIVELED MEAT.

Much trouble is experienced with walnuts in certain seasons on account of the meat being shriveled and poorly developed. This affects some varieties and some individual trees more than others and is often much worse the same year in certain localities than in others. The trouble is more apt to affect varieties which come out late in the spring than those which develop early. It is usually, though not always, worse on such varieties in the southern part of the State than in the northern, and this indeed is one of the principal reasons why very late varieties are not adapted to southern California. A tendency toward this trouble is one of the worst faults of the Eureka in the southern part of the State, and the same is true of Franquette, Hale, Concord, San José, and in fact almost every late variety that has been tested in southern California. The northern part of the State is by no means free from this trouble, but it is less common there and is usually confined in certain seasons to certain localities, although it does not affect the same locality every year. In 1911, for instance, the Franquettes were quite generally poorly filled and light meated in Sonoma County, while in the vicinity of San José and Stockton such was not the case. In other or, in fact, in most years, Sonoma County Franquettes have been as well filled as any. The cause of this poor development or shriveling of the meat has been ascribed to various influences, none of which have been positively proven to bring about this trouble. The influences suspected have been the same as those to which perforation or non-development of the shell have been laid, namely poor pollination, lack of soil moisture, and the attacks of the walnut aphis. Which of these actually causes the trouble has not been positively determined. In the southern part of the State it is probable that the

pollination of late varieties is hindered by extremely dry weather which is likely to occur at the time when they are in bloom, and it is also true that during the season of 1911 late spring frosts occurred in many localities in the northern part of the State, which may have interfered with the proper setting of the crop. Aphis has likewise been very abundant during the last two or three years, and this condition has been coincident with short rainfall and lack of soil moisture, especially in the subsoil. While the disease cannot at present be attacked specifically, we believe that its control, along with that of perforation, yellow leaf, and, in fact, most of the troubles which affect the walnut will be greatly contributed to by the control of the aphis and attention to proper irrigation of the subsoil. The latter can usually be readily accomplished where irrigation water is available and the grower should watch carefully the moisture condition of his subsoil in dry years by actual examination down to a depth of at least six feet. Where no irrigation is possible dry farming methods should be systematically pursued, consisting in deep plowing so as to catch as much as possible of the winter rainfall and deep and thorough summer cultivation to retain such moisture in the ground. The control of aphis we discuss under the next heading.

APHIS.

The walnut is comparatively free from insect enemies, and we shall not attempt to present a complete description of every insect which may at times be found attacking the tree. One enemy of this sort, however, is of particular importance and should be mentioned here. This is the green aphis or plant louse. This insect has become so abundant during the past two years on walnut trees of almost every species all over the State that it may be considered fully as important as the much dreaded walnut blight.

The walnut aphis is a small, soft, green insect which occurs on the under side of the leaves, often in considerable abundance. The insect itself is less conspicuous than the secondary effects which it produces. These are, first, an abundant secretion of honeydew, a sticky, liquid substance with which the foliage and the ground or vegetation beneath the trees becomes covered. The second conspicuous effect consists in the development of a black, smutty mold which grows upon this honeydew and covers the leaves and fruit of the walnut and everything else upon which the honeydew has dropped. This insect and its attendant effects have always been common in occasional seasons, but during the past two years there has been an unusual prevalence of aphis in most parts of the State, both on English and black walnut

trees. The insect feeds by sucking the nutritive juices from the foliage of the tree and when abundant it may injure the tree to no little extent by so doing. In dry years, when the trees are already somewhat weakened, the bad effects are increased. It is also probable that the tree is injured more or less by being coated over with honeydew and sooty mold. The insect multiplies most freely in seasons or places of rather cool, moist, summer climate, and is largely suppressed by continuous hot sunshine. Its effects are therefore worst in regions near the coast. In addition to the direct injury to the tree caused by the aphis and its honeydew, there is some possibility that these effects are connected with perforation of the walnut and also shriveling or poor development of the meat. In all events these troubles usually occur together, and years when there is an abundant development of aphis, there has also usually been more perforation and more poor meats. This may be the effect of the insect or it may be that all these troubles occur more abundantly under the same conditions, particularly in a season following a dry winter. Another well-established effect of the aphis is connected with the spread of the walnut blight organism. There is no question that these insects in crawling about and puncturing the leaves spread the blight to a considerable extent. All in all, therefore, we believe that the control of aphis is one of the most important problems of the walnut grower if the insect continues to develop as it has during the past two or three years.

APHIS CONTROL.

The only feasible means of controlling this insect appears to be by spraying with the most effective substance at the most effective time. No definite experiments have been made along this line, nor has the insect ever been carefully studied so far as we are aware.[1] It apparently winters over upon the walnut tree, probably in the egg form, so that it may be possible by a winter spraying to exterminate the insect during the dormant season. Various winter spraying of walnuts has been done by different growers, using lime-sulphur and other similar sprays. The results of such spraying as to aphis control seem to be somewhat doubtful. Some have thought that much benefit was obtained, the amount of aphis during the following summer being much reduced, while others could see no such effect. Summer spraying is effective against many other kinds of plant lice, and there is no reason why the walnut aphis could not be controlled in the same way, except that the trees are large and the spraying expensive. Mr. George

[1]It is described and illustrated by E. O. Essig in The Monthly Bulletin, Cal. State Com. of Hort., Vol. 1, No. 5, p. 190.

Williams of Goleta has done a considerable amount of summer spraying with a tobacco spray with very satisfactory results. The following mixtures may be suggested for work of this sort.[1] In applying them a special effort should be made to spray the under side of the leaves, as this is where the insects are found. Spraying should be done as early in the season as possible in order to exterminate the insects before they multiply. It is hoped that systematic experiments along this line may be made during the coming season.

Soap Solution.

Soap	1 pound.
Water	5 to 15 gallons.

Whale-oil or fish-oil soap preferable, but for small amounts any yellow laundry soap will answer.

Tobacco Soap.

Blackleaf 40	1 pound (1-10 gallon).
Cresol soap, 1 gallon or whale-oil soap	10 pounds.
Water	200 gallons.

The cresol soap requires no heating.

BLISTER MITE—ERINOSE.

This is a very common trouble of the walnut tree but not a serious one. Its effects are seen in the form of blister-like swellings or elevations on the leaf surface, which are convex on the upper and concave on the lower side of the leaf. These swellings are caused by numerous, very small insects which live within the blisters on the under side of the leaf amongst a felt-like, hairy growth which develops there. While this effect is very common, it produces no appreciable injury and needs no treatment for its control.

RED SPIDER.

This is a very small mite which sometimes becomes extremely abundant on walnut leaves, causing them to dry and even to fall from the tree. The insect is not ordinarily serious except in very hot climates, to which the walnut is not well adapted. In such situations red spider usually hastens the dropping of the leaves caused by too intense summer heat.

[1]Circular 66, Cal. Agr. Expt. Sta.

APPENDIX.

WALNUTS IN FRANCE.

We have thought it worth while to present excerpts from a translation of the following excellent article by Mr. F. Lousourd, taken from Revue Horticole, volume 83, 1911, pages 310, 329, 358, 378.

"We prefer to study the varieties by regions and have divided them into three groups.

1. Nuts of the Southeast.
2. Nuts of Central France.
3. Varieties Belonging to Various Regions.

This classification has some advantages; the varieties cultivated in the same region prove to be similar, and the comparison of characteristics is thus easy.

NUTS OF THE SOUTHEAST.

Mayette.—The Mayette walnut is large, slightly elongated, widened and flattened at the base, even slightly depressed toward the peduncle. It easily stands upright on its base, and this characteristic alone suffices to distinguish it from other varieties of the Isere to which it has some resemblance. The shell, half-hard, of a light amber color, terminates at the apex in an obtuse, somewhat pronounced point; it protrudes slightly along the suture of the valves from the lower third as far as the point. The average dimensions of the walnut are as follows: length 44 mm., breadth 34 mm.; it weighs, dry, from 10 to 11 grammes. A hectolitre (2.85 bushels) of the dry walnuts weighs from 30 to 33 kilogrammes (66 to 73 pounds).

The origin of this variety is very obscure. It gets its name from the name Mayet who, according to some, imported it from Naples and according to others obtained it from seed. It has been cultivated nearly one hundred and fifty years in the department of Isere, where it is located within the cantons of Tullins, Vinay and Saint-Marcellin. It is found on the well exposed terraces bordering both banks of the Isere from Moirans to Vinay.

Of all the varieties of walnuts cultivated in France, the Mayette is the most beautiful. The fine, fair shell, well filled, contains a kernel possessing the delicate flavor of the hazelnut. The nut for dessert is *par excellence,* and when the crop is light the merchants dispute over the price. It always sells for a greater price than other varieties; in an ordinary year it brings from 75 to 80 francs per 100 kilogrammes,

dry. (About 7 cents per pound.) The highest price for which this is sold ranges from 110 to 120 francs (10 to 11 cents per pound). It is always sold in the shell; it is exported to foreign countries, especially to the United States.

The Mayette is a walnut of Isere which dries better, and, at the same time, whose yield is most assured in a soil and climate which favors its culture. But this variety is very exacting and in the valley of Gresivaudan it scarcely exceeds an altitude of 400 meters (1300 feet above sea level); if it is cultivated beyond this limit, it loses in quality. On the other hand it requires fertile soil and abundant and regular manuring.

In spite of its quality, which places it in the first rank of table nuts, it is hardly probable that the Mayette will extend outside the area which it occupies in the department of Isere. Moreover, the agriculturists in regions producing the Mayette are making an effort to limit it. For some years there have been planted here and there (Haute-Savoie, Cher, etc.) some walnut trees of this variety; it is still too early to form any conclusions from present results.

The tree is vigorous and blossoms late but rapidly. In consequence it makes a fine sight. It is fitting to add that in the above mentioned cantons, the Mayette comprises nine tenths of the orchards. It constitutes orchards whose mass of stately trees give a picturesque aspect to the country. In a certain number of townships of Isere, the products of the Mayette tree form the principal resources of the agriculturist.

Parisienne.—The Parisienne nut is large, oblong and nearly as wide at the top as at the base. It stands less easily on the base than the Mayette. The point, the apex of the shell, is almost imperceptible. This is somewhat hard, rather rough and of dark color.

The average dimensions are as follows: length 40 mm., width 36 mm. The average weight of a hectolitre (2.85 bushels) of dry nuts varies from 30 to 33 kilogrammes (66 to 73 pounds).

Like the Mayette, the Parisienne is a special variety of the department of Isere. The crop is produced especially in the canton of Vinay and somewhat in the canton of Saint-Marcellin. The color is less fine than that of the Mayette, but the kernel is good and completely fills the shell. Although less choice than the Mayette, and selling for less, it is, nevertheless, one of the better varieties for dessert. It is less exacting than the Mayette and may thrive at an altitude exceeding 400 meters.

The tree is vigorous, flowering late and for rather long duration, which favors its resistance to spring frosts and assures regularity of crops. The crops are quite large.

Franquette.—This variety was found by Franquet, a litte less than a hundred years ago, close by the Notre Dame d'Osier (a town in the vicinity of Saint-Marcellin). The Franquette nut is large, elongated, narrow, exceedingly pointed, the apex terminating in a very pronounced point. The shell, hard and of a dark color (?), presents a pronounced depression along each rib of the line of suture of the valves; it is rough and very wrinkled. The green kernel fills the cavity well and the dry kernel is of good quality though inferior to that of the Mayette. The average dimensions are as follows: length 48 mm., width 37. The average weight of a hectolitre (2.85 bushels) of dry nuts varies between 33 and 35 kilogrammes (73 to 77 pounds).

The Franquette walnut is located in the department of Isere, where it abounds on the hills situated between Vinay and Saint-Marcellin. The tree is vigorous, spreading, flowering late; it produces regularly and thrives well in dry soil. The fruits are exported in shell to America. They bring on an average 5 francs less per quintal than those of the Mayette.

The three varieties described above (Mayette, Parisienne, Franquette) are designated in commerce by the name Noix de Grenoble (Grenoble nut).

Noix de Vourey.—The Vourey walnut is scarcely harvested except in the town of Vourey (Isere) and in neighboring localities. It has somewhat the shape of the Mayette, although it is smaller. It is a nut of average size, a little elongated, slightly flattened at the base, and terminating at the apex in a very pronounced point. The shell projects along the line of suture of the valves, extending from the lower third to the point. The average dimensions are as follows: length 35 mm., width 29 mm.

This is a nut of two purposes, good for table use and very good for the manufacture of oil. Its shell, very thin and tender, of a clear color, presents a good appearance; the kernel is of good quality. The Vourey nut is not held in reproach for its small size; but in spite of its size, it is sold partly in shell for dessert, and very often it is cracked and sold as green kernels which are fine and fill the shell well. From the last point of view it is a very choice variety. Besides, it bears from the third year. It is more precocious than the Mayette, the Parisienne and the Franquette.

The tree is vigorous, spreading and very productive. It blossoms late (on an average ten to twelve days after the Mayette and Franquette).

Meylan.—This is originally from Meylan (Isere), where its culture is nearly nil, nearly all the trees of the Persian type being on the road

to disappearance. But it is found here and there in the department of Isere.

This nut is large or very large, round, flattened at the base, slightly pointed at the apex. The shell, of a clear color, is soft and nearly smooth. The large, delicate kernel fills the cavity well. The dimensions are as follows: length 38 mm., width 36 mm.

The Meylan blossoms late and, for this reason, it escapes nearly all the spring frosts; its crop is a little more sure, especially in a year not wholly favorable for the production of the walnut. The tree is vigorous and very spreading. For purchase when mature, this variety is not as popular as the Mayette, which is ideal for dessert. It sells for a little less, but the tree being less delicate and less exacting as regards climate and fertility of the soil, the Meylan will give very good results in a place not suited to the Mayette.

Gautheronne.—The Gautheronne is little known. However, the trees, are scattered here and there in the canton of Tullins, (Isere). It has very much the shape of the Chaberte, but it is larger and its shell is smoother and the color clearer. It measures 40 mm. in length and 32 mm. in width. It is sold in the shell for dessert.

Chaberte.—This gets its name from Chaberte, its originator and propagator; it has been cultivated for a hundred and fifty years around the environs of the department of Isere. It is a nut small or of average size, a little elongated, slightly pointed, having a hard, wrinkled shell of dark color and very full; its kernel is delicate. The average dimensions of the nut are, length 35 mm., width 30 mm. The nut, dry, weighs about 9 grammes and the weight of a hectolitre (2.85 bushels) varies from 36 to 40 kilos (79 to 88 pounds).

The Chaberte blossoms late, almost as late as the Saint-Jean, which it replaces advantageously. The tree, vigorous and productive, yields regular crops. It is cultivated in Isere, within the plateau of Bizoir from Voiron to Lyons. It is found in all the districts except those of Saint-Marcellin. It is also cultivated in Savois, in the Drome and in a few departments in central France.

It is utilized for the manufacture of oil; and especially since the fresh kernels demand a high price, they crack the nuts and pack the kernels in cases which are exported to America. According to M. Rouault, Departmental Professor of Agriculture of Isere, the yield of oil is 64 per cent or 12 litres (10.8 quarts) of oil to 20 kilograms (44 pounds) of kernels, but in practice they count on one litre of oil to 2 kilograms of kernels. The Chaberte (oil) pays at most from 26 to 32 francs ($5.20 to $6.40) a hectolitre (26½ gallons), a price which is rarely exceeded; in ordinary years it varies from 15 to 28 francs per 100 kilos ($3 to $5.60 per 220 pounds).

Petite Ronde.—The Petite Ronde, peculiar to the department of Drome, where it is principally cultivated in the districts of Die, is, as its name indicates, a nut of small dimensions. It measures on an average 31 to 32 mm. in length by 30 mm. in width and weighs, dry, from 6 to 7 grammes. A hectolitre (2.85 bushels) weighs 40 kilos (88 pounds).

It is almost as wide as it is high, large at the top and slightly depressed from the shoulder to the point, which is small, but projecting. The shell is rounded in the region of the base, which makes it rather unstable on its base. The shell projects a little along the line of suture of the valves in the upper half.

The Petite Ronde is of a beautiful dark yellow color; it is cultivated for sale fresh (for confectionery) and for sale of the fresh kernels. There are 3 kilograms (6.6 pounds), 500 green kernels, in a double decalitre (2¼ pecks) of walnuts. The tree blossoms late. It yields large crops.

NUTS OF CENTRAL FRANCE.

Careme.—The Careme is a little elongated, having a medium point and a shell flattened and also slightly and irregularly depressed at the base. The shell is projectile along the suture of the valves extending from the middle. It is thin, tender, with a dull, very wrinkled surface. It is of average size, 36 mm. in length by 32 mm. in width. The average weight of a dry nut is 8½ grammes and the weight of a hectolitre (2.85 bushels) varies from 34 to 36 kilos (75 to 80 pounds).

The Careme is principally cultivated in the department of Aveyron, particularly in the district of Villefranche-de-Rouergue; the greater part of the walnut trees of the department are of this variety, which has for its origin an old and magnificent tree situated on the route from Capdenac, one kilometer to the north of Villeneuve. This old tree has a trunk measuring only 2 to 2½ meters in height, and strong limbs which extend laterally through a radius of from 10 to 12 meters; it has formerly yielded as much as 6 hectolitres (17 bushels) of nuts. It is this which has furnished grafts for nearly all the trees in the country. The tree is spreading and bears well.

The Careme is sometimes sold for the table. It is very much valued for the sale of the green kernels. Its shell is thin and the kernel fills it well, with no waste space, the kind of nut which has little waste in breaking. To-day they do not manufacture much oil, but formerly, when the price of nuts was lower, preference was given to the Careme nut for the manufacture of oil. They obtained, with the primitive presses, a dozen litres of oil from 2 hectolitres of nuts. The nuts were sold in 1910 for from 20 to 25 francs a hectolitre ($4 to $5 per 2.85 bushels).

Gourlande.—The Gourlande nut is very large, elongated, oval, with shell deeply and irregularly sinuate, pointed at the apex. This shell is extremely fragile and when dry it breaks and shatters with the least shock. Therefore, the Gourlande is difficult to preserve dry. The handsome nut measures 48 mm. in length by 40 in width and weighs, dry, from 13 to 14 grammes. The average weight of a nut is 11 grammes.

The Gourlande is cultivated only in the department of Puy-de-Dome. It is found in the townships of Chamalieres, Cebazat, etc. It is much sought by confectioners. It is harvested when the kernel is still white and the shell gelatinous. They pick them partly green and preserve the kernel. The green nuts sell for from 25 to 40 francs per 100 kilos ($5 to $8 per 220 pounds). A mature tree furnishes perhaps 150 kilos (330 pounds) of green nuts for the confectioners.

They never keep the Gourlande nut to eat dry; nevertheless, it is frequently sold fresh in August or September as a table nut. It is rarely kept for the manufacture of oil; moreover, the crop is less by one tenth that of the ordinary nut (noix commune).

The seed bed is the only method of propagation in use; in no practice, it appears, has the Gourlande been propagated by grafting. Those who have tried various systems of grafting have been disappointed. By means of the seed bed, they obtain trees of which two thirds are degenerate and ought to be rejected; there is, in consequence, a great waste.

Corne.—The Corne nut, still called Coutras, Corne-de-bœuf, has a half-hard shell. It is elongated, of ovoid form, of average size and very pointed at the apex. The shell is of clear color with surface irregular and deeply sinuate; it is depressed in the upper half along the line of suture of the valves. The two valves are solidly sealed which qualifies it for a good dessert nut, easy of transportation and of long preservation. The kernel is fine and white. The average dimensions are as follows: length 39 mm., width 30 mm. The average weight of a dry nut is 8 to 9 grammes and the average weight of a hectolitre (2.85 bushels) 37 to 39 kilos (81 to 86 pounds).

The tree is vigorous and very productive; it blossoms generally at the end of May.

The Corne nut is very popular in Lot. It is found in the environs of Montvalent, Rocamadour. They cultivate it as well in Dordogne (Sarladais) and also in Aveyron. Very choice in commerce, by reason of the hardness of its shell and fineness of its kernel, it is spreading (in commerce) to the detriment of other varieties. In 1910 it sold for from 45 to 50 francs for 50 kilos or 90 to 700 francs per quintal.

Nave or Noix du Lot.—The Nave or Noix du Lot resembles the Corne both in shape and in appearance. The shell is clear, ovoid, quite pointed, slightly projecting along the line of suture of the valves in the upper half; the shell is tough and hard to crack; it is less wrinkled and more uniform than the Corne; it is much less elongated at the apex and more flattened in the region of the point. The Nave is of average size; it measures 39 to 40 mm. in length, 29 mm. in width. The average weight of a dry nut is 8½ grammes and the weight of a hectolitre 36 to 38 kilogrammes in a good year; in 1910 the weight was only 34 to 35 kilogrammes. The nut of Lot is very precocious and always comes in a dozen days before other varieties. It is much appreciated for commerce and exportation for the two following reasons: Because the hard shell allows it to sustain handling without breaking and arrive intact in America; because it is harvested early, which permits the commencing of shipping about the 15th or 20th of October, while the other varieties are not ready for exportation till in November. They cultivate it in the environs of Cahors and in the south of the department of Lot.

The Noyer du Lot blossoms late, May or June; they harvest the nut to the end of September; the merchants buy the dry nuts from the producers. Discarding the culls, they sulphur the nuts and send them to Bordeaux and to Germany.

Lelande.—The Lelande is elongated, terminating at the apex in a very pronounced point; the shell, very irregular and deeply sinuous, is unsymmetrical at the base and a little flattened. The line of suture of the valves is very projectile, especially in the middle. This nut has a shell of clear color, thin and very tender, breaking easily; it is unsuitable for transportation. The fact that its kernel is fine and plump makes it a choice nut for commerce, put up in boxes and for sale as green kernels. The average dimensions are as follows: length 41 mm., width 30 mm. The average weight of a dry nut is 9 grammes and a hectolitre of dry nuts weighs from 35 to 36 kilogrammes.

The Lelande is cultivated principally in Correze and Dordogne. In certain parts of Correze this variety is replaced by the Marbot, which is more productive, larger, having a shell a little harder which can stand transportation; the Marbot also sells for a little more.

The tree attains an average size; it is very vigorous but it blossoms early which makes the crops irregular. The yield is large when the late frosts do not destroy the flowers. The Lelande nut sells on an average of from 15 to 20 francs per hectolitre; in 1910 the price reached 37 to 40 francs; in 1900 it was worth from 10 to 12 francs and in 1909 from 20 to 22 francs. A hectolitre (2.85 bushels) of nuts makes from 15 to 16 kilogrammes (33 to 35 pounds) of kernels containing 50 to 55 per cent oil.

Marbot.—The Marbot is large or very large, terminating in the upper part in a projecting point small and very sharp. It is flattened at the base and stands perfectly upright. The shell, irregularly sinuate, is depressed along the line of suture of the valves extending from the lower third to the top. It is a nut with a tender shell, but sufficiently firm to bear transportation.

The Marbot is especially cultivated in the department of Lot and particularly in the environs of Vayrac, Gramat, Saint-Cere, and in the entire north of the department. It is likewise cultivated in Correze and in the environs of Maysac. It is larger than the Noix du Lot. Its average dimensions are as follows: Length 43 mm., width 38 mm. The average weight of a dry nut is 12 grammes and the average weight of a hectolitre from 32 to 33 kilogrammes.

It is very valued in commerce as a dessert nut. The tree blossoms from the end of April through May; it produces very regular and satisfactory crops.

Gros Jean.—Likewise called Noix de Figeac. The fruit is large or very large, having thick, hard shell from which the meat is with some difficulty detached. The nut is a little elongated, oblong, slightly flattened at the base, but it does not stand upright very evenly. At the apex it terminates in a point, strong and sharp. The shell is hard and wrinkled; the line of suture of the valves is projectile, extending from the lower third to the region of the point. The average dimensions are as follows: length 42 mm., width 32 mm. The average weight of a dry nut is $9\frac{1}{2}$ grammes and the weight of a hectolitre from 38 to 40 kilogrammes. The best nut weighs from 11 to 12 grammes. The kernel is of good quality.

The tree attains large dimensions; it is vigorous and very productive, but it takes the original fertility from the soil. The nut, by reason of the hardness of the shell which makes it difficult to break, is less suitable than other varieties (Candelon, Lelande, Grand Jean) for the production of the green kernel; on the other hand, it is excellent for sale in the shell. It is cultivated in Lot in the neighborhood of Souillac and in the district of Sarlat (Dordogne). It is cultivated also in the environs of Figeac where it is propagated under the name Noix de Figeac.

Grand Jean.—This variety is a little elongated, flattened at both ends, terminating in the upper part in a point almost imperceptible. It stands perfectly upright upon the base. The shell, projecting from the lower third along the line of suture of the valves, is thin and tender and well filled with a delicate white kernel. The average dimensions are as follows: length 37 mm., width 30 mm. The dry nut weighs on an average of 9 to 10 grammes and the weight of a hectolitre varies from 35 to 37 kilogrammes.

The tree is vigorous and very precocious. By reason of its early flowering it requires a warm exposure. It grows well in sandy soil. The Grand Jean is very desirable for the sale of green kernels; it is a variety much sought by the markets of Sarlat (Dordogne), Souillac and Gourdon. It is cultivated in the districts of Sarlat. It yields abundantly in the canton of Saint-Cyprien extending from Buisson to Domme; it is found, likewise, in the highest canton.

Candelou.—The Candelou is a small, slightly elongated nut with thick and very pronounced point; the shell is irregularly flattened at the base in a manner which does not permit it to stand upright. The line of suture of the valves is a little projectile, extending from the middle to the top. The shell, tender and thin, is very uniform and does not adhere to the green kernel, which makes breaking easy and rapid. The kernel is sightly and of good quality. The average dimensions are as follows: length 34 mm., width 30 mm. The average weight of a dry nut is 8 grammes and the average weight of a hectolitre is from 35 to 36 kilogrammes.

The Candelou is especially cultivated in the department of Lot and particularly in the region of Gourdon and Souillac; it is also cultivated a little in Dordogne in the part neighboring on the district of Gourdon.

The tree blossoms very late. The kernels are especially suited to be packed green in boxes. It is too small for the table. In 1910 it brought from 36 to 38 francs per hectolitre.

Noix de Brantome.—The Brantome nut is originally from Brantome in the district of Perigueux (Dordogne), where it is considerably cultivated.

It is a small walnut, a little elongated, having a tender shell of amber color whose surface is a little wrinkled. It is slightly flattened at both extremities. The point is almost nil and the line of suture of the valves is slightly projecting. The average dimensions are as follows: length 35 mm., width 28 mm. The average weight of a dry nut is 8 grammes and a hectolitre weighs from 37 to 38 kilos.

It blossoms early (commencing in May) and the trees are rather exposed to late spring frosts.

In localities where the Noix de Brantome is cultivated, it is still used for the manufacture of oil. Every cultivator ordinarily lays by three hectolitres of nuts to make a pressful of kernels, from 35 to 40 kilos. The yield is 50 per cent oil.

The grafted nut of Brantome is very productive when the year is favorable; because it is precocious, it is sent off fresh in good time for the markets of the large cities of France or foreign parts. They sell it for dessert and for the green kernels. The green kernel of the Noix de Brantome is from 38 to 40 per cent of its total weight.

Its culture has a tendency to diminish. They plant in preference, the Corne, which produces more regularly and gives a fruit selling at least 8 to 10 francs more per quintal.

Redon de Montignac.—This variety is peculiar to the department of Dordogne; it is cultivated in Montignac and surrounding district of Sarlat. It is a small nut having half hard shell, of a dark color. The line of the suture of the valves is projectile, extending from the middle to the point. The shell is rather smooth and slightly flattened at both extremities. The average dimensions are as follows: length 30 mm., width 26 mm. The dry nut weighs about 7 grammes and the weight of a hectolitre of dry nuts reaches 38 kilos.

The Redon de Montignac is a variety which blossoms early; the flowers are in full bloom in April and May and are exposed to the late frosts. Some years ago this nut was almost exclusively used for the manufacture of oil and by reason of its yield it was preferred to other varieties. To-day the nuts are cracked on the place and exported in the form of green kernels, which tends to replace the Redon with the Lalande, a nut of greater value and larger size. Nevertheless, at the present time the Redon de Montignac is still very popular.

Anguleuse.—The Anguleuse (angular), being a nut with a hard shell, is the fruit of the *Juglans regia angulosa* (*J. r. dura*). It is a nut of average size, having a very hard, thick shell presenting angles parting at the middle and rejoining at the apex to form a sharp point. It contains a kernel rather hard and difficult to extract whole on account of the hardness of the shell. The dry nut weighs about 10 grammes and the weight of a hectolitre is from 34 to 35 kilograms.

This variety, which is found in Dordogne and Lot, yields fruit utilized for the manufacture of oil. The wood is of good quality and often veined.

Noix a Grappes.—It is the fruit of *Juglans regia racemosa.* The variety is very curious, for the nuts are collected in a bunch, comprising 12, 15 and even 20 or 24 fruits. They are small and weigh about 6 grammes dry.

The Noyer a Grappes is found here and there in Indre, Vienne, etc. The variety is very productive. A single tree produces from 3 to 4 hectolitres of nuts (8½ to 11 bushels). The Noyer a Grappes is a spreading tree, slightly exacting and suited for the production of nuts intended for the manufacture of oil.

Noisette.—The Noisette nut is produced by a tree having small fruit (*Juglans regia avellana, J. r. microcarpa*). The fruit is, as the name indicates, very small, globular, having hard, full shell containing a white kernel, delicate and very rich in oil. Notwithstanding the small-

ness of the fruit, the tree is productive. It is cultivated a little everywhere in the department of Dordogne.

Nogarelle.—The Nogarelle or Petite Impente is a variety rather recently brought to attention and still slightly known in cultivation. It is found in Dordogne extending from Buisson and along Dordogne to Lalande. It is of average size, a little smaller than the Grand Jean and having a tender shell. It is recommended for agriculture because of the large crop of green kernels.

VARIETIES OF VARIOUS REGIONS.

Commune.—The Noix Commune has distinct characteristics. It is a small nut having hard or half-hard shell, somewhat flattened at the base, slightly pointed at the apex, containing a kernel fine and rich in oil. The average weight of a dry nut is from 6 to 8 grammes and the weight of a hectolitre about 40 kilos. One hundred kilos of nuts make on an average 40 kilos of kernels and 100 kilos of kernels yield, by pressing, 50 kilos of oil.

The Noyer Commune blossoms in April or the beginning of May, before its leaves commence to push through. As a result of its early blossoming, it is exposed to the attacks of spring frosts and its crops are very irregular. It is propagated exclusively from seed and as the selection of the nut is rarely practiced, the trees obtained present great differences as regards crops. It is cultivated in all departments; it is an oil nut *par excellence.* In places it could be advantageously replaced with good varieties which blossom late and which could be propagated by grafting.

Noix de la Saint-Jean.—This variety is thus named because the tree does not blossom until the month of June, much later than other varieties, which permits the tree to escape spring frosts.

The nut is small, round, of a dark color, having a tender shell enclosing a kernel rich in oil. The kernel instead of being white, as in good varieties, is of a yellow color. The line of suture of the valves is very much projected in the whole circumference and especially in the region of the point and base; the shell is very wrinkled. The average dimensions of this nut are as follows: length 37 mm., width 34 mm. The average weight of a dry nut is from 7 to 8 grammes and the weight of a hectolitre from 38 to 40 kilos.

Because it blossoms late, the Noix de la Saint-Jean is recommended for the parts of the country subject to frost (north and central). The fruit is especially suited for the manufacture of oil. It produces regularly and abundantly. The tree grows rapidly; its wood is some-

times veined with black, often presenting rings which add greatly to its value; the bark is brown and deeply fissured.

Noix a Bijoux.—The Noix a Bijoux or Noix de Jauge is the fruit of the "walnut tree having large fruit" (*Juglans regia maxima*). It is a nearly square nut, having wrinkled shell, flattened at the sides, with the line of suture of the valves slightly projecting; it is somewhat pointed at the apex and depressed at the base, which permits it to stand resting on the base. Its shell, thick, breakable, contains a kernel of ordinary quality which never fills the cavity well. The dimensions of the nut, in general, are 4 to 5 centimeters in length with equal width. Its average dry weight is 15 grammes.

This variety is curious in the exceptional dimensions of its fruit, but from the culture point of view it is of slight importance. Its fruits are generally distributed in clusters of two or three; they are much sought by jewelers for making jewel boxes. The tree requires a fresh and fertile soil; it grows rapidly and its wood is of inferior quality to that of the Noyer Commune.

Fertile.—This variety was found by M. L. Jamin about 1838, on the grounds of M. Louis Chatenay, nurseryman of Duoe-la-Fontaine (Maine et Loire).

In size it is medium or small, having roundish oval form, with soft, well filled shell. The tree is rather vigorous and remarkable because it bears the third year; unfortunately it blossoms early, often exposing the crop to frosts.

The Fertile nut comes sufficiently true from seed.

Noix a Coque Tendre.—The nut with tender shell, also called the Noix a Mesange (titmouse) and the Noix de Mars, is small, elongated, pointed, tapering at both ends. The shell is very delicate and breaks with the least shock; birds, often by hundreds, feed upon the kernels, whence its name Noix a Mesange. The shell is well filled and contains a good and very oily kernel. The average weight of a dry nut is 8 grammes and the weight of a hectolitre from 40 to 44 kilos.

The early blossoming exposes it to spring frosts; it should be in a sheltered place and well exposed to the sun. When the year is favorable it yields large crops. The tree is very large and vigorous; it has the fault of sending out a great many shoots before bearing. Its bark is white and delicate and the wood often veined in black. The nut is harvested early, a part being on sale fresh for the table. The greater part is utilized for the manufacture of oil and for packing in boxes for green kernel sale.

Barthere.—This variety was obtained in 1860 by a nurseryman, Barthere, of Toulouse. The characteristics of this nut are its long,

flattened appearance, half-hard shell of clear color. The shell is well filled and its kernel of good quality. The tree is vigorous, fruitful, portly and erect. The nuts mature late; they are harvested in October.

Noix a Cerneau Rouge.—The Noix a Cerneau Rouge (*Juglans regia rubra*) is an old variety. It is mentioned for the first time (1763) by the Dutch pomologist Knoop and afterwards pointed out by various others. This variety was completely lost sight of. It has been recognized after twenty years at Gratz (Styrie), where there is a good specimen.

The nut is rather large, of ovoid form, having a shell half-hard, very dented and well filled. The kernel, as in many varieties of hazelnuts, is covered with a blood-red or carmine-red membrane; it is of good quality.

The tree is identical with the Noyer Commune and possesses the same vigor. It is reproduced sufficiently well from seed and bears before the eighth year. This information was obligingly furnished by M. Jouin, director of the Simon-Louis nurseries at Plantieres near Metz. This is established by noting down information from those who have grown the Noix a Cerneau Rouge.

ACKNOWLEDGMENT.

In the eight or nine years, during which the observations and investigations reported in this bulletin have been under way, numberless suggestions, ideas, and bits of information have been obtained from a great many different people, some of whom have been mentioned in the body of the publication in connection with various subjects. It is impossible, however, to give full individual credit for everything of this sort. We can only say, in general, that almost all of this information is the result of continued observation, correspondence, and conversation carried on from year to year in all parts of the State where we could learn of any possible source of information concerning walnuts. To all of those who have so willingly helped us during this work we wish to express our most sincere appreciation. To Messrs. S. F. and Frank A. Leib, of San José, W. W. Fitzgerald, of Stockton, and J. B. Neff, of Anaheim, we feel especially indebted for many suggestions and ideas which could not be individually credited in the bulletin. Special mention is also due to Mr. Edgar A. Metcalfe, our expert propagator, who has worked out many of the ideas contained in the bulletin, especially those upon budding the walnut. The majority of our suggestions upon propagation have come from the work of Mr. Metcalfe and that of Mr. George Weinshank, of Whittier.

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1897. Resistant Vines, their Selection, Adaptation, and Grafting. Appendix to Viticultural Report for 1896.

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No. 55. Farmers' Institute and University Extension in Agriculture.
60. Butter Scoring Contest, 1910.
61. University Farm School.
62. The School Garden in the Course of Study.
63. How to Make an Observation Hive.
64. Announcement of Farmers' Short Courses for 1911.
65. The California Insecticide Law.
66. Insecticides and Insect Control.
67. Development of Secondary School Agriculture in California.
68. The Prevention of Hog Cholera.
69. The Extermination of Morning-Glory.
70. Observations on the Status of Corn-growing in California.
74. Rice.
75. A New Leakage Gauge.
76. Hot Room Callousing.
77. University Farm School.
78. Announcement of Farmers' Short Courses for 1911.
79. List of Insecticide Dealers.